HOUSE ORGAN OF O'ALLOYS GENERAL ALLOYS COMPANY

ALLOY PROGRESS

EDITED BY H. H. Harris PRESIDENT

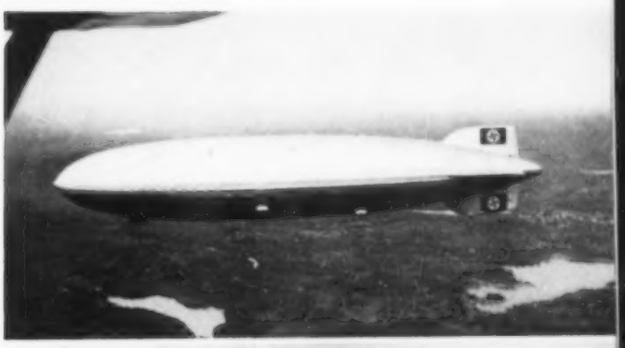
Bright Spot in Metal Progress

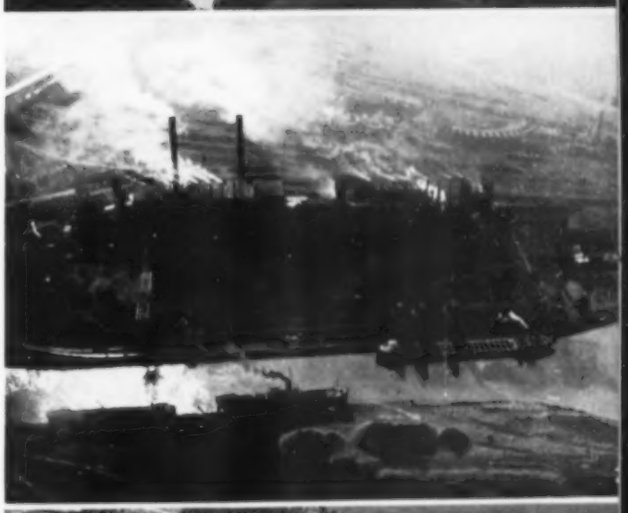
ENTIRELY ABOUT HEAT & CORROSION RESISTANT ALLOY CASTINGS

Rhyminiscent

As I pause from press of business to pen this idle rhyme,
I'm taking inventory, for it's inventory time.
But it's not the stock I'm checking, nor dollars lost or won,
That concern me in accounting when final statements done.
I am thinking of the "life" I've spent, the things I've done and said,
The things I cannot figure in the black or in the red.
I am thinking of the men I've met in plants throughout the land,
Who've given of their time to me, held out a friendly hand.
Who placed a certain confidence in statements that I made,
And staked their judgment on my claims and on the game I played.
I am thinking of the fellows who have gone out of their way
To help me put my stuff across . . . they do it every day.
I see friendships that are ripening, that have stood the test of years,
Have I kept faith with those who trusted, or am I in arrears?
What are dollars, few or many, to record commercial strife
When checked against the finer things along the path of life?
In intercourse with fellowmen, the give and take of trade,
The profit of enduring worth is not the dollar made.
I am humble as I contemplate how little I can say or do
To show that I appreciate what Men . . . one may be you . . .
Have done to aid me on my way.

H. H. Harris





ROGER, WHA DO YE MAKE O' THIS JIGGERWHACK, BEASTIE?
WEEL, DANNY, 'TIS A CROSS TWIXT MUG AND MALLET TO ENCOURAGE LITERACHOOR AND LIBATION.

Alloys Progress solicits contributions, and offers ONE JIGGERWHACK to each contributor whose contribution is published. News, Humor, Metallurgy, personal notes, candid snapshots. If we print it, you own a Jiggerwhack. Nippy Gadget, what?

We will send, with our compliments, an 8 x 10 enlargement of any one of the above aerial photographs to any *member of A.S.M. whose company operates a Heat-Treat, or makes Heat-Treating equipment.*

General Alloys Company, 367-405 W. First St., Boston, Mass. Please send one 8 x 10 enlargement of No. .. Skyview, flown and photographed by H. H. Harris.

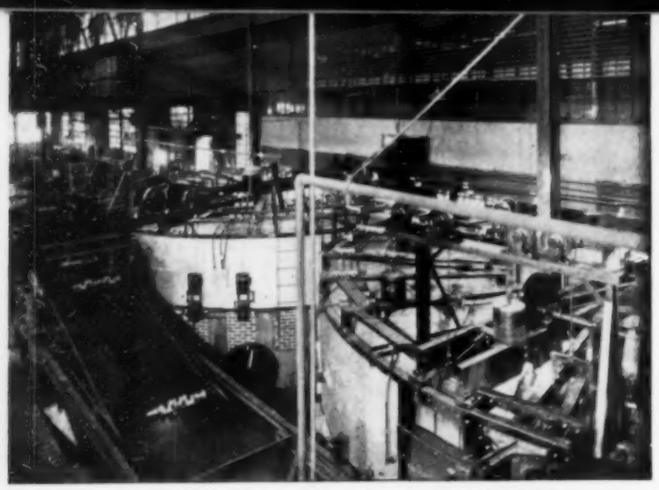
To .....

(Name) ..... (Title) .....

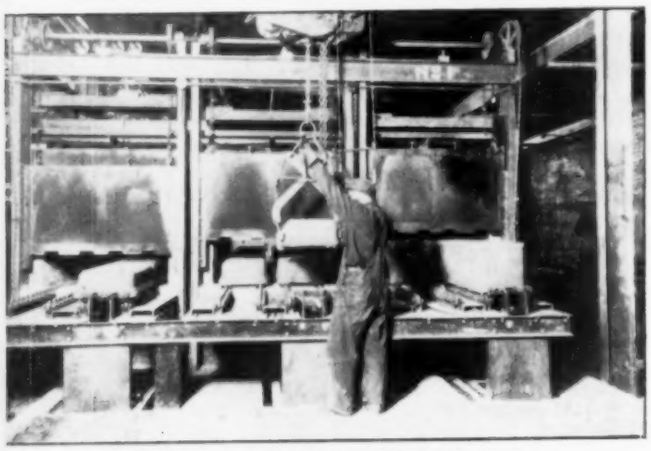
(Company) .....

(Address) .....

No furnace is better than its Alloy Parts



THE REPUTATION OF LEADING FURNACE BUILDERS



IS BASED ON THE PERFORMANCE OF SUCH

X-ITE EQUIPT VETERANS AS THESE

THIS Post-Depression Number of Alloy Progress is, or should be, a harbinger of prosperity. Alloy Progress hung on until the last dog had the halter around his neck, and General Alloys never missed an issue of Metal Progress, exhibiting every steel show. We could wait a few years before continuing Alloy Progress and still have run more advertising with A.S.M. than all competitors combined.

ALLOY Progress started as the "Box Bulletin" in Transactions of A.S.S.T.—good old "Steel Treaters," went aristocratic with Metal Progress and became "Alloy Progress," running eight to twelve pages. A.P. was reprinted and distributed to a list of eight thousand non members A.S.M., thus having a larger circulation than any two "Metallurgical" publications. It may again.

WE are, frankly, experimenting. Reader re-action will determine future policy. There was an inspiring camaraderie in the old "Steel Treaters," back before Bill Eisenman's barn burned down, back before Bill had a barn, but we've lost intimacy in dynamic expansion.

I don't know if I can still bat the Corona to this crowd, or must go hi-hat and dictate to a stenographer. Times have changed. Ferro-maneurium is Apscray X-rayed, and there is so much advertising in editorial pages of "Trade Journals" that my conservative stuff may be too weak a mixture.

THRILLING to fine craftsmanship, and any departure from the mediocrity called "Style." I get a kick out of this unique small car, designed and built by B. F. Harris, formerly of this company, and now a consulting designer. The cross-flow radiator, flow-line design, disappearing headlights, etc., are no less novel than the 100% special V-8 engine, front wheel drive chassis designed around remarkable new Spicer Universal Joints. Do-

ing 50 miles to the gallon, 100 miles per hour, safe handling and economy at high speed due to scientific design, this doodlebug is a step in the revolution of tomorrow toward today. If it hit something, you'd have a chance of walking away, for it's "Crashproofed" *(next need in motor cars).*

SPEAKING of crashes, our old friend Major D. M. (Dal.) Speer, 8,000 hr. pilot, recently fell asleep driving, cut down 150 ft. of brush, including a 6" tree, jumped an 18 ft. embankment, landed upside-down, slid 200 ft. on the roof, and suffered a strained arm. "Sleeping is much safer in the air" says Dal.

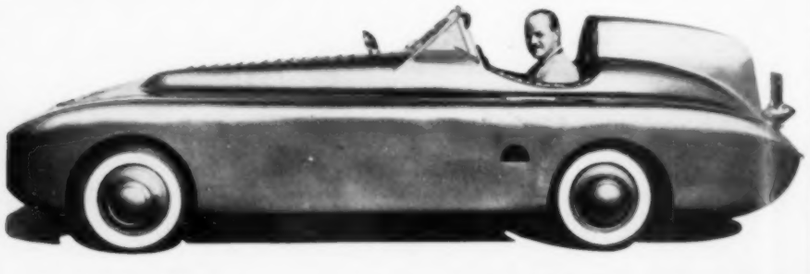
THE only "unpleasant" incident attending the Steel Show, was the staccato candor of the Statler Hotel. Before the last Steel Treaters had departed, the Statler Marquee blared forth "Welcome Exterminators and Fumigators." *Tactless, to say the least.*

I only bang this thing to charm you while we sterilize the needle. If I could play another instrument, I'd quit practicing. That's fair warning. Read further and you'll get a shot of propaganda, but—we'll try to ease the pain with a picture, a laugh, and some really helpful and reliable information on alloys.

WHATEVER you think of my down wind landings on the Corona, you have to admit that General Alloys has progress to report, and that if experience means anything, you can count our competition on the fingers of a crippled hand.

WE have made much progress, metallurgically, and in design, during the depression years, as recent patents, savings to users, and tonnage sales eloquently testify;—a mere beginning!

TREMBLING to the tramp of the Roman legions in Ethiopia, Umberto d'Atri, General Alloys Designer, has had black-buck fever and triggeritis for months. Charging the Maine woods with or for deer. Bert plugged a black bear on dead center, made the papers. Now he is gunning for Blondes to set off the black bear rug, reversing the American hunting order.



THE FOOTPRINTS OF GENERAL ALLOYS
GA X-ITE GA GA X-ITE

WITH the Sports Department in session, credit must be done to that unparalleled marksman, S. Floyd, (Sam to you) Keener, Prost-Salem Eng. Co., just returned from an extensive European engagement, on the Bremen, abdicating one week ahead of Edward. Sam is shown with his record breaking bag of Cape Gazelle, taken by sheer strategy.

THE economy of flying the modern airplane is surprising. For the last three hundred and fifty hours on my Fairchild Cabin Airplane, I have averaged thirteen

miles to the gallon of gas and twelve hundred miles to the gallon of oil. Not a valve has been ground or a sparkplug changed. Radio, battery, instruments, tires, brakes, landing lights, have all functioned perfectly. A good buggy. Flying always bored me. I like to snooze in the air.

Now that Mrs. H. has her pilot license I can catch up on my sleep.

FLYERS get odd squints at things. One strong reminder of my coal bill slid by while passing St. Louis, a coal yard built like a dollar sign. Sunrises and sunsets, the moon, and clouds are particularly beautiful from the air. Most beautiful is a great city at night, the myriad lights like sparkling jewels on miles of velvet.

FREDDY REPORTS TO THE BOSS
by Hal Chase

Ed. Note: Freddy is salesman-at-large for the Porous Castings Co. Just another steel foundry philandering in the alloy business.

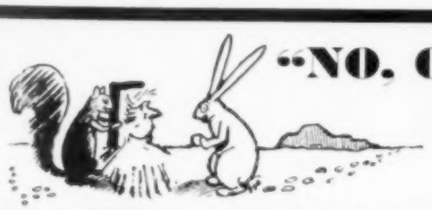
Dear Jake—

Here I am in Peoria after makin' a fast trip through the farm belt. I came up through Iowa the first of the week and spent the night at three farmhouses without once gettin' a farmer's daughter. Was I disillusioned! ! ! Believe it or not, Jake, news travels so slow out in this neck of the forest that some of these agrarians think Landon still has a chanst. They ain't got over the drought yet. One old baby with a chin fringe of tobacco juiced G strings told me it was so dry out there that the telegraph poles were chasin' the dogs around. They tell of one of the Tiller boys who rose with the crack of dawn to mangle the sod. He

tied a plow to his nags and started the day's labor. The grasshoppers were so thick that they ganged up and chased him clean outa the cornfield. He finally stopped behind a coupla bushes and looked back. Whata you s'pose, Jake? Them grasshoppers had et up the two horses and the harness and were pitchin' horseshoes to see who'd take the first bite outa the plow.

I hired that guy in Long Bottom, Ohio. His name is Al, short for Alfalfa only they call him Timothy because he can always be found in the hay. He spends most of his time in the bed room. Just another old chamber mug. The way he puts in the rib for everybody but himself is brutal. They oughta named him porcupine on accounta he's always givin' somebody the needles. He used to be a file salesman and he still has a rasp in his voice. He tells me of a tough P.A. who asks him what kinda files he sells, so he tells him a coupla Mickey Mouse stories. He then told the P.A. he could keep them for a coupla rat tails. The P.A. tells Tim that he wouldn't take nothin'. He said he was 600 Brinell and that made him file proof.

(Continued on Next Page)



"NO, CHILDREN . . SANTA . . . . . IS NOT IN THE ALLOY BUSINESS" . .

When you buy alloys, or anything else for that matter, you get what you pay for, sometimes less. If you want cheap materials come out frankly and say so, don't kid yourself by getting prices on four or five different grades of alloy and then buying on price.

In buying steel you don't expect to get a high duty steel from a mill rolling concrete reinforcing bars. Use the same amount of discretion and consideration of basic economics in purchasing alloys and you will buy quality to obtain service.

There is no substitute for experience, no substitute for sound engineering, and no Santa Claus in either your business or ours.

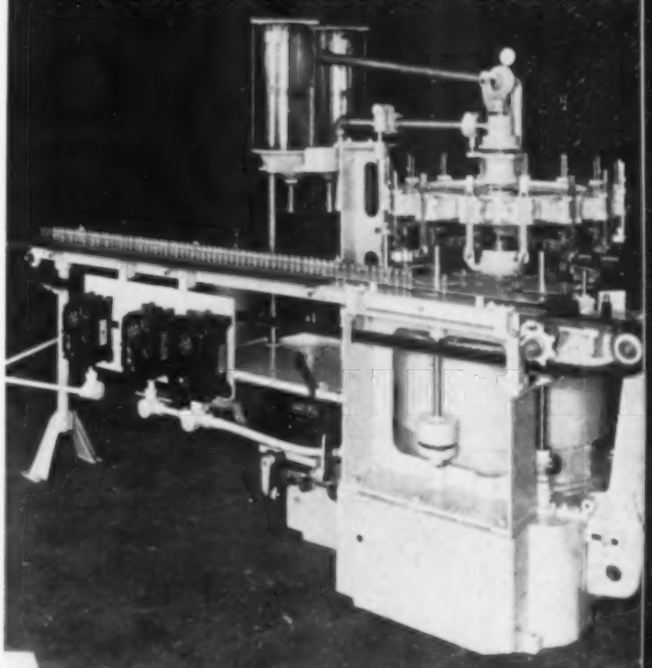
The dependability of Q-Alloys is a known quantity.

HELL ON FOOT DANDRUFF but ABSORBINE JR. is like Taps to Q ALLOY CN-1

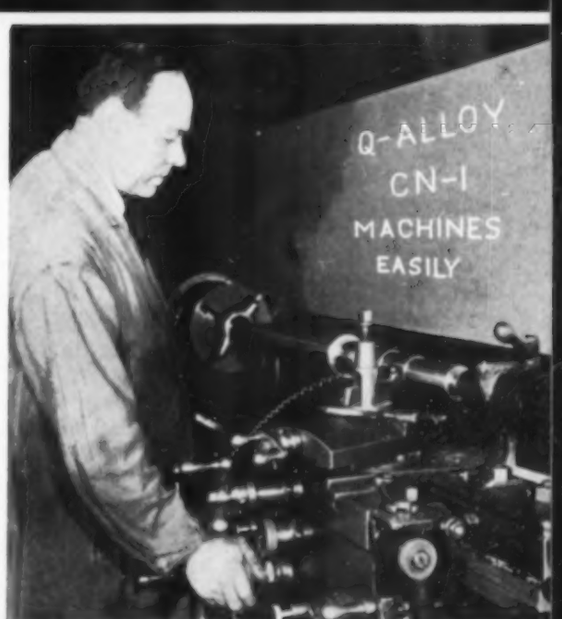
All parts of this machine in contact with the product are Stainless Steel and Glass. All Alloy Castings by General Alloys Company

An outstanding achievement in modern packaging machinery by a world famous manufacturer.

PRECISION MECHANISMS REQUIRE PRECISION CASTINGS



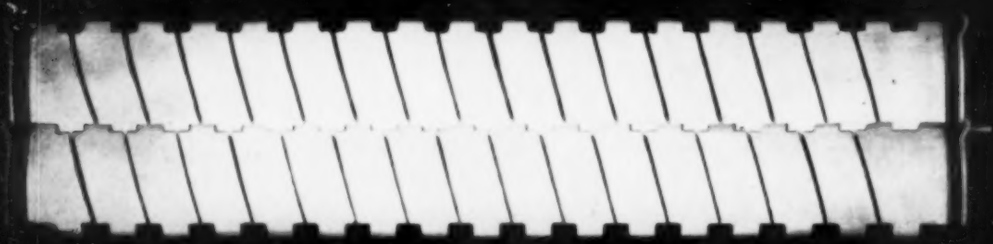
PNEU-ROTARY VACUUM FILLER
by Pneumatic Scale Corporation Limited Quincy, Mass.



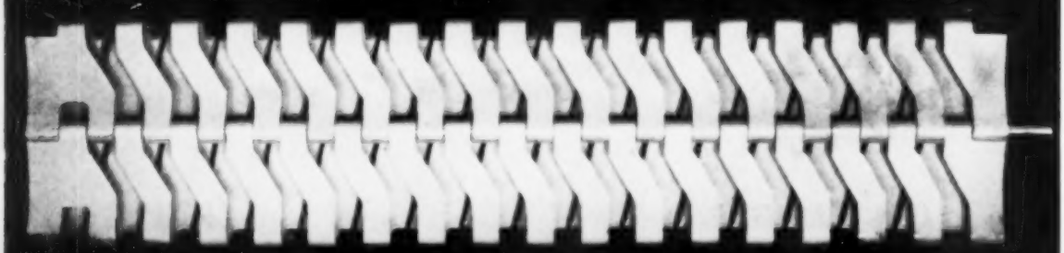
BECOME THE PATH OF AN INDUSTRY
GA Q'ALLOYS
GA X-ITE
GA Q'ALLOYS
GA X-ITE

SPIRALINK
CONVEYOR FURNACE HEARTH

H. H. HARRIS PATENT NO. 2-045-646



Note that either of these assemblies is but two castings pinned together with a rod — not 34 separate castings as might appear at first glance. And instead of 136 machining operations there are precisely none.



An "impossible" casting for most foundrymen, for it is the most exacting alloy casting job in existance, just an every-day job with General Alloys.

RADICALLY NEW • STRONGER • BETTER • CHEAPER

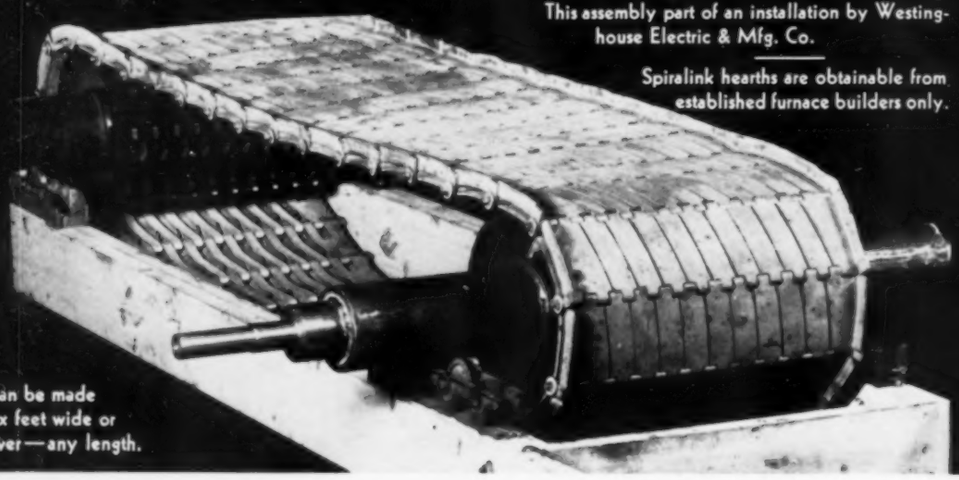
This is the latest engineering contribution from the manufacturer who has built more cast-link hearths than all competitors combined. One of a series of outstanding improvements in furnace mechanisms by H H. Harris. Others will follow.

The slots can be cored as thin as $\frac{1}{16}$", and the wall section is held to less than $\frac{1}{64}$" tolerance. A design to take advantage of General Alloys superb foundry practice, cast to such precision that the weakening of structure by machining the dense hard "Skin" from the casting is eliminated.

This Spiralink Belt hearth can be made in a variety of sizes and specific design. It is so flexible (transversely) laterally that one link can be bent 90 degrees and spring back, yet it gets away from the longitudinal stretch of fabricated wire and strip belts. (Obviously, any alloys soft enough to roll and draw into wire lack the strength and stiffness inherent in X-ite castings.)

This assembly part of an installation by Westinghouse Electric & Mfg. Co.

Spiralink hearths are obtainable from established furnace builders only.



Can be made six feet wide or over — any length.

I go over to see that heat treat punk who wants to buy a pot. I lets this mug Tim do the chatter just to see what kind of a line he spills. The heat treat guy tells him he wants to get a pot to try out some new salts. Tim asks him if he's goin' to run hardenin' salts. The h.t. punk, bein' a wise guy, tells Tim that they was softenin' salts.

"Just a minute," says Tim, "we're in the metal business; not the crockery racket."

This palooka Tim certainly doesn't know nothin' about the steel business. He thinks a rod mill is a place they make gats, and a strip and sheet mill is a Turkish bath. He tells me his handicap is visitin' her folks, so he's on the loose. He also intimates that it would be a swell idea to do a little gallopin' with a coupla bambalinas. I ain't nailed down either, so he calls up a coupla gidgies. The one he got for me used to be governess to Queen Elizabeth. He tells me they call her Europe because she had her map made over so many times. This dame says she's a playwrite. She's workin' on a play now called "Cheatin' Cheaters." It's the story of a guy who wore spectacles without no lenses in them. And they choke carburetors!

Tim's dame insists on me indulgin' in a little of the gentle art of that guy Terpsichore, with her as my toddlin' little playmate. She's kinda plump around the middle and I ain't no sprite myself, so we did a sailor's hornpipe. You know, one of them naval dances.

Hopin' that pout pussed dame in Rounds Corners don't find out where you're workin', I am,

Yours,

Freddie.

FREDDIE PICKS AN ALL-AMERICAN ELEVEN

LEFT END: Joe Nectardeth—What an end!

LEFT TACKLE: Kelley (spell it with an "E") Pool. They call him 8 ball because the whole team finished the season behind him. Wise cracking leader. He gooled 'em when he cracked, "Your son can get hot in a sun room but he can't swim in a pool room." The boys call him Pooly on accounta he can block and tackle.

LEFT GUARD: Satan. The guy who replaced the shovel pass with the pitchfork play. Great guy for a tail back. Horns in on every play. Can be depended upon to keep the going hot.

CENTER: Charley Rumhound. A great nose for a ball; can always be found leaning over one. A great guy on fumbles. Can outfumble anyone when it's time to pay up.

RIGHT GUARD: St. Pete. Greatest guard that ever played for the Notre Dame Irish. Known as the Guardian of the Harps. Try to get through him.

RIGHT TACKLE: Sam Redcap. Always training. Meets all the coaches. Marvelous on a tackle around play as he sure can carry the leather. He got that snake hip action by watching the rattlers.

RIGHT END: John Barleycorn. Can always be depended upon to break loose when apparently bottled up. Lays all tacklers out in rows.

QUARTER BACK: Footsie Carnera, the Gargantuan Gorgonzola. The man who disproved the theory that there was three months to a fall by proving every fall was seven feet. Great guy at blocking the leather (with his chin). Learned his signals remembering telephone numbers while abroad. Went around with a lot of famous women. Ran the Noted Dames ragged. Great kicker. Holds the record for the longest boots.

LEFT HALF BACK: Jupe Pluvius. The guy who caused so much trouble by refusing to play in the Dust Bowl. What a job he can do on a dry gridiron. Once he starts he's all over the field. Practically ruins a passing attack.

RIGHT HALF BACK: Mickey Finn. Great interfering back. Only guy to eliminate both ends in one play.

FULL BACK: One Eye Connolly. Wonderful in crashing plays. His guard crashing is recognized as supreme from coast to coast. Great pass snatcher. Has been known to make the grade without a pass.

COACH: Joe Tritt. A great guy for digging up material. Shook the slot machine to get his quarter back.

UMPIRE: Leeds. }
REFEREE. Northrup. } No matter how hot the going gets they always have everything under control.

GENERAL ALLOYS COMPANY

367-403 W. FIRST ST., BOSTON, MASSACHUSETTS, U. S. A.

PLANTS

BOSTON, MASS.

CHAMPAIGN, ILL.

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DETROIT — 4-137 General Motors Bldg.

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BUFFALO — 812 Tacoma Ave.

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CLEVELAND — HAL W. REYNOLDS, 3346 Superior Avenue

MILWAU... — C. R. SLENDE... 1412 Bankers...

DAYTO... — A. H. TALENT... 1926 So. Main...

OLDEST AND LARGEST EXCLUSIVE MANUFACTURER OF HEAT & CORROSION RESISTANT ALLO...

Liquid brazing

(Continued from page 74)

of 0.04 in. was introduced by means of ridges. As the spacing was increased toward this limit, the tensile strength of the brazed joints increased, giving 25,000 to 27,000 psi. with 0.03 in. spacing. It therefore appeared that spacing of this order would be necessary to effect the most reliable brazing.

In order to measure the maximum spacing accurately, plates of mild steel ¼ in. thick and 4 in. square had one surface ground plane. The plates were riveted together in pairs to form a wedge-shaped air space between them, being kept apart at one end by a steel wire 0.06 in. diameter. This wedge was brazed in normal procedure, the joint being subsequently examined.

It would appear from the above experiments that good brazing could be produced with any spacing up to the limit where the brass runs out, although this has not been found to be the case in production. Hence it appeared that some other factor might be responsible for the flaws met with in practice.

Further studies of the flaws in joints made in production indicated that these cavities were filled with borax when the spacing was excessive, but where the spacing was small these appeared to take the form of clean holes, typical of gas inclusions. It therefore appeared that some gas was being trapped in the brass at these tight joints. Since this work was done with brass at about 2000° F., a temperature where the vapor pressure of zinc is considerable, it seemed probable that part of the escaping zinc vapor might be trapped in the narrow spacings between the blades and sections.

A series of similar segments was therefore brazed at temperatures 100° F. lower, which showed marked improvement as to soundness, and (when spacings were carefully controlled at 0.01 to 0.03 in.) very good strength. A further lowering of 100° F. was not successful.

Hence it appears that a borax temperature of about 1825° F. (brass at 1900° F.) is the best for the brazing of these segments.

With regard to the spacing necessary between blade and section, the tensile results from the numerous experiments carried out show that the wider the spacing the stronger the joint up to the limit where the brass runs out. This appears to occur when the spacing exceeds 0.032 in. The most satisfactory spacing appears to be about 0.025 in., and attempts should be made to maintain this uniform on both sides of the blades. With spacings much less than this, any inclusions of either gas or borax have less opportunity of being expelled, while with larger spacings, there is danger of the brass running out.

FINE TOOL STEELS FOR EVERY PURPOSE
A GOOD TURN
The "P.A." said: "We'll try it."
The Machinist: "It works up fine."
The Hardener: "It tempers nicely."
The Boss: "It sure did me a good turn."
Vulcan Special Vanadium
will do you a good turn too if you want a better cold work tool steel.
VULCAN
CRUCIBLE STEEL COMPANY
ALIQUIPPA, PA.

CAPACITROL
Compels
INSTANTANEOUS
CONTROL
The instantaneous action of the CAPACITROL No-Contact—Radio Principle holds any desired heat DEAD ON THE LINE, minimizing fuel consumption, eliminating danger of furnace or load damage, offers new low initial and operating cost and guarantees quality production. Engineering data and prices furnished on request.
WHEELCO INSTRUMENTS CO.
1112 MILWAUKEE AVENUE • CHICAGO

LAVITE

The only heat treating baths that do not deteriorate with use and that do not injure the work treated.

TEMPERING LAVITE—275°-1200° F.

Tempering Lavite is a clean, stable liquid throughout this wide temperature range. It does not fume or deteriorate with use. No other tempering medium has these advantages. Lavite tempering means rapid, uniform, clean, economical and consistent duplication in heat treatment.

CARBON LAVITE (H OR C H)—1000°-2000° F.

H for Hardening C H for Case Hardening

Carbon Lavite is the best medium for heating carbon and alloy tool steel parts such as gears, taps and threading dies, reamers, hobs, cutters, knives, gun parts, drills, stamping and forming dies and punches. Carbon Lavite C H is not only the best means of getting hard deep cases with tough core but it is the quickest and most economical case hardening method known. The quickest, cleanest heat without warpage or decarburizing.

ANNEALING LAVITE—1000°-2000° F.

Annealing Lavite is the ideal medium for heating ferrous metals such as steel wire in production ton lots, or non-ferrous metals, as gold jewelry blanks in ounce lots. Different grades are used for different metals, Copper, Nickel, Nichrome, Monel, Sterling, Gold, Aluminum, Brass, Bronze, Iron and Steel.

HIGH SPEED LAVITE

High Speed Lavite is used for heating high speed steel and has a working range of 1750° to 2500° F. It is generally used at temperatures from 2150° to 2350° F. for the hardening of high speed steels.

LAVITE FURNACES

The new Lavite Furnaces provide a method of heating that eliminates burning out of pots, overshooting of temperatures and deterioration of the furnace from excessive temperatures. The resistance of the Lavite to the electric current between electrodes gives heat only where it is needed; the thermal efficiency from this method of heating is so high that the cost of electricity is frequently considerably less than is possible with any type of gas or oil heated furnace.

If you are already a Lavite user, there will be other applications of Lavite in your shop that will save you money and improve your product. Let us tell you how others are applying Lavite on similar work.

Made only by

THE BELLIS HEAT TREATING COMPANY

BRANFORD CONNECTICUT

Inclusions in steel

(Continued from page 68)

There were left the methods involving the use of iodine and chlorine, and the authors tabulate numerous results showing the action of these halogens on various steels and also on various oxides and other compounds and mixtures of these.

It is not practicable to detail here the very interesting results obtained, but it may be mentioned that under controlled conditions of attack, the same total oxygen content was obtained on plain carbon steels by both the iodine and chlorine methods, although the amounts of the individual oxides differed. The figures for Al_2O_3 were in fair agreement but the values for SiO_2 were higher and for FeO and MnO lower by the chlorine method. The authors suggest a tentative explanation for this based on the fact that chlorine, at even 500° F., has a slight attack on FeO and MnO, and that the increase in SiO_2 follows from the combination of the oxygen thus liberated with some of the silicon dissolved in the steel.

In the light of all these results, they conclude that the value of any selected method of determining inclusions cannot be assessed with certainty and that only by the closest coordination of every branch of metallurgical experience will the amount and character of non-metallic inclusions be determined. It is interesting to note that they themselves examined their residues with X-rays, and were able, for example, to show definitely the presence of MnS in residues obtained by the iodine method from ordinary carbon steels and of Fe_3P in residues similarly obtained from high phosphorus cast irons. They conclude that manganese sulphide is not completely soluble and iron phosphide is practically insoluble in the iodine solutions employed.

The difficulties in estimating these inclusions accurately are likely to arise from several causes, of which their complex nature, due to the numerous possible combinations of the oxides likely to be present, is not the least important. The work of Colbeck and his colleagues, however, should be regarded as an incentive to further work in solving this important, though admittedly difficult problem and not as decrying the value of the methods which have already been proposed for its solution.

J. H. G. Monypenny

handicaps your equipment

. . . *trim it Off!*

WHAT is dead weight, you ask. Briefly we define dead weight as that part of the weight of any equipment which can be eliminated economically through light-weight design employing modern high tensile steels.

Dead weight, in other words, is needless weight—excess poundage that costs you money every time you move it. It adds its costly load to your power plant . . . increases wear on parts . . . slows up operation . . . limits capacity. Dead weight is a perpetual drag on earnings—it has no place in modern machine construction.

Today engineers and designers are waging a ruthless battle against the waste of dead weight. Among their most potent and economical weapons are USS COR-TEN and USS MAN-TEN. The greater tensile strength, the increased toughness, and the greatly increased corrosion resistance of these new low-alloy, low cost steels have made it possible to build industrial equipment as much as 30% lighter—yet without any loss of strength, safety or endurance. In countless applications this weight reduction has been translated into greater capacity—lower operating costs — increased revenue.

That is why "Built of COR-TEN" or "Made of MAN-TEN" is today a recognized mark of a superior product.

If your equipment is built of old-fashioned, conventional steels why not find out how much tare weight you can safely get rid of—and what it will cost to eliminate it? Our engineers are fully competent to answer these questions. If the change over to light-weight construction will not justify its cost, they'll be the first to tell you. Write us, send us your blue-prints; we welcome the opportunity to assist you.

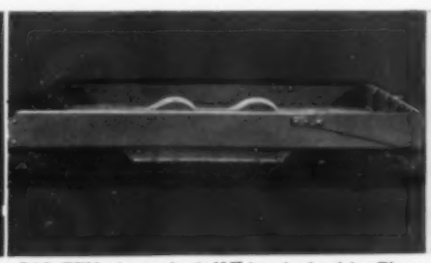
Mine Cage Built 30% lighter with MAN-TEN. *Vertical ore skip and double-deck hoisting cage built by the Allis-Chalmers Mfg. Co., Milwaukee, for the El Potosi Mining Company of Mexico. Replaced old cages of same capacity — is 30% lighter, permitting cage to reach mine level 800 feet lower without increasing rope pull on hoist . . . saved buying new hoisting equipment.*

U·S·S HIGH TENSILE STEELS

AMERICAN STEEL & WIRE COMPANY, *Chicago and New York* · CARNEGIE - ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago* · COLUMBIA STEEL COMPANY, *San Francisco* · NATIONAL TUBE COMPANY, *Pittsburgh* · TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*

Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Products Company, New York, *Export Distributors*

"The Rex modern cone drum of the Rex Moto-Mixer is built of USS MAN-TEN steel of 80,000 lbs. tensile strength for lighter weight, greater strength and longer life. We find that it resists the abrasive action of pounding concrete inside the drum and consequently will prolong the life of the mixer." (Chain Belt Company, Milwaukee, Wis.)



COR-TEN mine car hauls 19% less dead weight. *These cars stand but 20" above the rail yet have full level capacity of 105 cu. ft. 225 of them were recently built of COR-TEN by the American Car & Foundry Co. In 39" coal, the car capacity is practically four tons—they weigh 525 lbs. less than those built of ordinary steel.*

UNITED STATES STEEL

CHAR
CARBURIZERS

Low
DUSTING LOSS

The wear-resistant properties of the heavy carbon shell and the sealing of the energizing material within the particle combine to give CHAR CARBURIZING COMPOUND a very low dusting loss.

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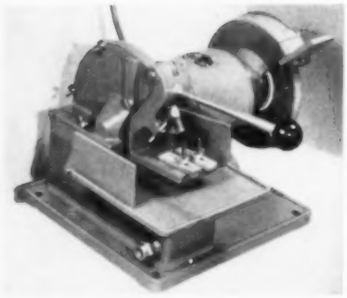

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A new tool for the Metallurgist. Indispensable for cutting Metallurgical specimens to convenient sizes. Safe to operate, safe for your specimens. High power and speed, water stream or tank cooling, easy to control. Specimens up to 1¼" are held on a newly designed swing-arm holding device, which guarantees perfect radial and axial alignment. Larger specimens may be cut also.

228 North La Salle St. Chicago

Adolph I. Buehler
OPTICAL INSTRUMENTS • METALLURGICAL APPARATUS

Vanadium in steel

(Continued from page 52)

tion, reduction of area, and notched bar impact figure, but the limit of proportionality was always a little lower in the specimens which had been hardened from the highest temperature. The microstructure in all cases showed uniform, fine grained sorbite. Oil-hardening from 1650° F. was thought most suitable.

When specimens quenched in that manner were tempered within the range 900 to 1200° F., the steels containing no vanadium showed a progressive decrease in ultimate strength, yield point (load giving 0.2% set) and proportional limit, and a progressive increase in reduction of area, elongation and Izod impact. However, when the vanadium content is between about 0.15 and 0.30% the mechanical properties are notably constant in this tempering range.

In confirmatory tests on other specimens, the same characteristics of the vanadium-bearing steel compared with those of the steels free from vanadium were observed. Molybdenum in the quantities up to about 0.7% conferred no "temper hardening" characteristics on the steel.

The reason for the above constancy in mechanical properties is thought to be the retention of vanadium carbide in solution in the alpha iron formed at the gamma-to-alpha transformation and its subsequent precipitation on reheating. This was discussed in the previous paper.

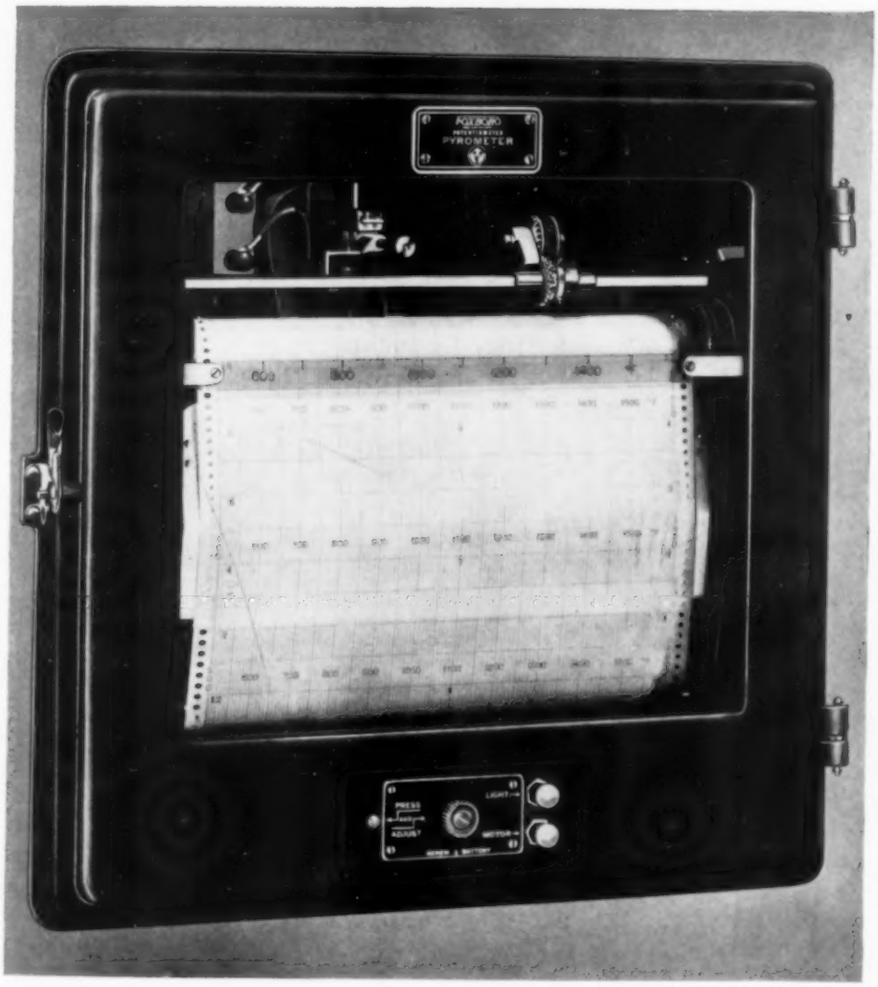
Vanadium carbide is dissolved in gamma iron less readily than iron carbide, and steel in which some of the carbon is combined with vanadium does not attain its full hardness when quenched from the usual temperature. If, however, the hardening temperature is raised and more of the vanadium carbide dissolved, higher hardness is obtained on quenching.

Any deduction as to the maximum useful vanadium content in these steels is complicated by the fact that attainment of the full hardening effect of the vanadium is dependent on the use of a high initial temperature of cooling in air or oil. On the other hand, a hardening temperature above 1650° F. is usually accompanied by serious practical disadvantages, and in the steels under consideration it also entailed a lowering of the limit of proportionality and of the notched bar impact figure, though the deleterious effect on mechanical properties was not as pronounced as in carbon-vanadium steels. All the steels consisted of uniform sorbite, and the austenitic grain size was not greatly affected by an increase in hardening temperature to 1750° F.

The results obtained indicate that if the hardening temperature is limited to 1650° F., the most suitable vanadium content in nickel-chromium and nickel-chromium-molybdenum steels of the types investigated is 0.15 to 0.25%.

SILENT ACTION..

for accuracy and long life



"Quiet as a mouse" well describes the operation of a Foxboro Pyrometer. This silence in action and minimum wear go hand-in-hand. It assures long life in a recording system which operates at moderate speeds but which gives rapid recording.

Response to thermocouple temperature changes is instantaneous, and the extra compensating slide wire means more uniform sensitivity over the entire scale. Moreover, Foxboro offers a type of record to fit each need – from a single line to 8 individual records on a 12-inch wide chart.

All the advantages of this modern Potentiometer Pyrometer Recorder are given in detail in Bulletin 190-1. A copy is freely offered. The Foxboro Company, 52 Neponset Ave., Foxboro, Mass., U.S.A. Branches in 25 Principal Cities.

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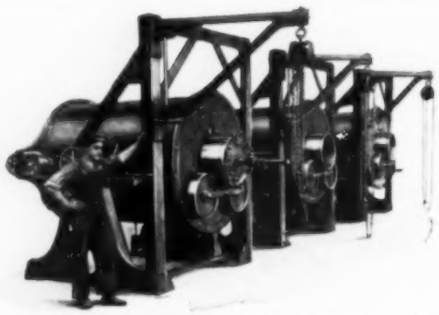
PYROMETER RECORDERS

RESPONSE · ACCURACY



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Engineering Representatives in Principal Cities.

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for welding all corrosion and heat resisting products. Send for data book.

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Aging of duralumin

(Continued from page 45)

(d) The 0.1% proof stress markedly increases with the amount of deformation, when tested 250 hr. later. This for the aged and non-deformed duralumin was 35,000 psi., for the specimen quenched and stretched 2.7% it was 41,500 psi., for the ones stretched 9.0% it was 51,000 psi., and for 14.2% stretch it was 64,000.

In contrast with these results plastic deformation after complete age hardening at air temperature produces:

(a) An instantaneous increase in hardness and decrease in elongation roughly proportional to the measure of deformation employed, which changes are virtually stable and smaller in amount than brought about by the same degree of deformation applied immediately after normalizing.

(b) A large increase in proof stress and a smaller one in ultimate stress, roughly related to the measure of deformation, giving rise to a material having better mechanical properties than if the same degree of deformation had been carried out directly after normalizing.

This is brought out by an extensive table, from which may be selected the following values for aged material *A* elongated 9.0% immediately after quenching, and material *B*, fully aged, then elongated 9.3% and aged 174 hr. before testing:

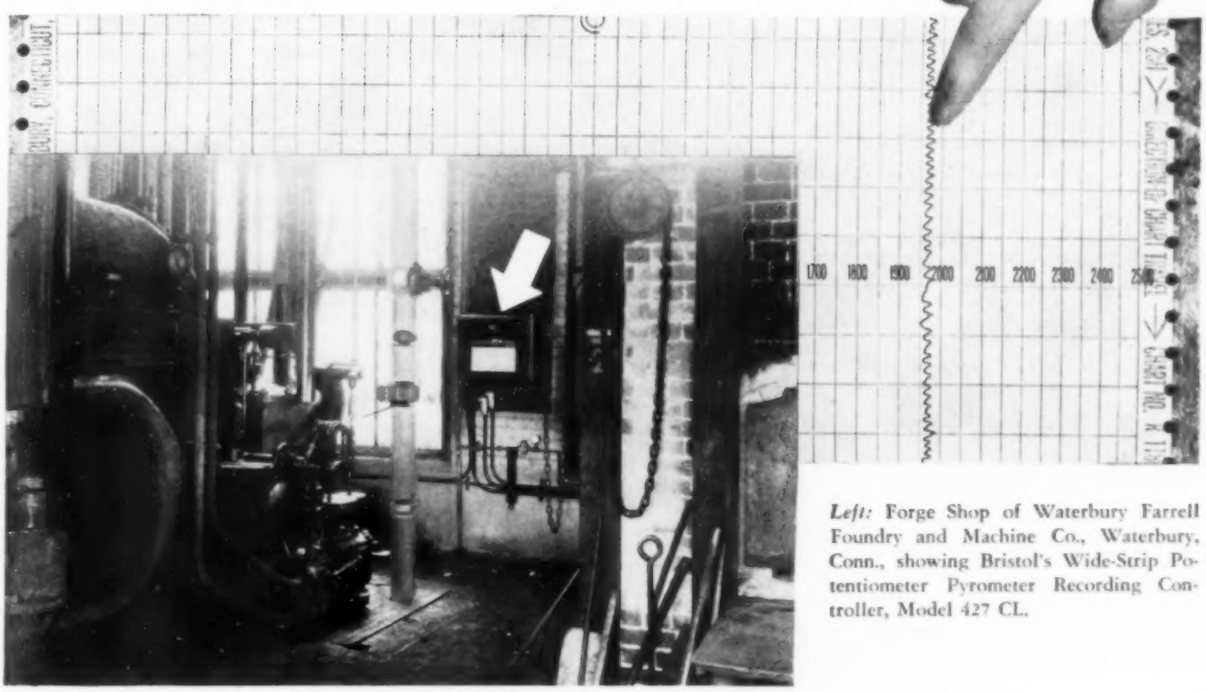
	Metal A	*Metal B*
0.1% Proof stress	50,500 psi.	59,500 psi.
Ultimate stress	57,500 psi.	63,500 psi.
Ratio of above	87.9%	93.8%
Elongation in 2 in.	11.0%	11.0%
Hardness (Vickers)	116	135

For the user of duralumin for structural purposes, the results emphasize the desirability of carrying out plastic deformation *subsequent* to age hardening, whenever this is possible, for the resulting mechanical properties of the alloy will be markedly superior to those obtained if this deformation *precedes* aging.

From the point of view of one attempting the by no means simple nor uncontentious task of constructing a wholly satisfactory theory of age hardening, the experiments described are certainly not opposed to the thesis of precipitation from supersaturated solution; indeed, in the author's opinion, which he offers with a diffidence justified by experience, they may be regarded as giving support to this now generally accepted view.

FORGING QUALITY *starts here*

IN THE FORGING FURNACE



Left: Forge Shop of Waterbury Farrell Foundry and Machine Co., Waterbury, Conn., showing Bristol's Wide-Strip Potentiometer Pyrometer Recording Controller, Model 427 CL.

Waterbury Farrell Foundry and Machine Co. find Bristol's automatic temperature control promotes better forgings, saves fuel

THERE CAN'T be any compromise with temperature at the forging furnace. Either it is right, — or it isn't.

Because extreme accuracy of temperature control is called for, and because such precision must be secured under conditions which are of unusual severity, the Waterbury Farrell Foundry and Machine Company have installed a Bristol's Wide-Strip Potentiometer Pyrometer Recording Controller.

The sample chart illustrated shows how closely forging furnace temperatures are controlled. For details of the control employed, write for Catalog 1451A.

THE BRISTOL COMPANY, WATERBURY, CONNECTICUT. Branch Offices: Akron, Birmingham, Boston, Chicago, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis, Seattle, San Francisco Canada: The Bristol Company of Canada, Limited, Toronto, Ontario. England: Bristol's Instrument Company, Limited, London, N. W. 10

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YOU can make every day in the new year a happy one for yourself and your Blast Cleaning operators if you will decide now to modernize your Shop with new Pangborn equipment units.

Scale, rust and dirt can be removed quickly and economically from heat-treated dies, gears, tools, etc., with Pangborn Air or Airless Blast Cleaning Equipment.

Pangborn Airless ROTOBLAST Barrels, Tables, Cabinets and Special Machines are the latest sensational developments for cleaning schedules where finest finishing is desired at lowest cost per ton.

Pangborn standard compressed air Cabinets are usually recommended for smaller, manually controlled cleaning.

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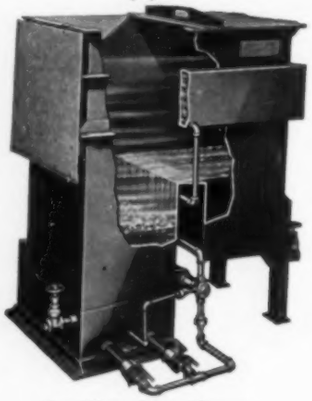
Authorities Agree...

"Metal products must be clean — free of oil and grease — before heat treating, and the most suitable cleaning process is Solvent Degreasing."



Size 623 gas heated Detrex Degreaser.

The Detrex Solvent Degreasing process makes use of stabilized safety solvents, either Perm-A-Clor or Triad. It completely removes oil and grease. The work comes out clean, warm, dry, and ready for subsequent heat treating or finishing operations.

Make a plant trial of the Detrex process without equipment investment. Prove to yourself its advantages of speed, economy, and efficiency.

Write for complete information. Also, copy of new booklet entitled "Scientific Metal Cleaning."

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Degreasers • Solvents • Alkali Cleaners

Invisible rays

(Begins on page 56) some tobacco plants 15 ft. high instead of 3 ft., as is normal, while other seeds from the same pods are dwarfs. Furthermore, the seeds from the giant plants reproduce giant plants. Not only is the size of the plant changed, but in many instances its basic form is changed also. The dream of the biologists of changing the hereditary characteristics of animals and plants — to make and control variations and to originate new species at will — seems to have been realized. These are greater changes than Nature would produce by evolution in thousands of years. Life itself seems about to yield to the instrumentality of the invisible rainbow in man's hands.

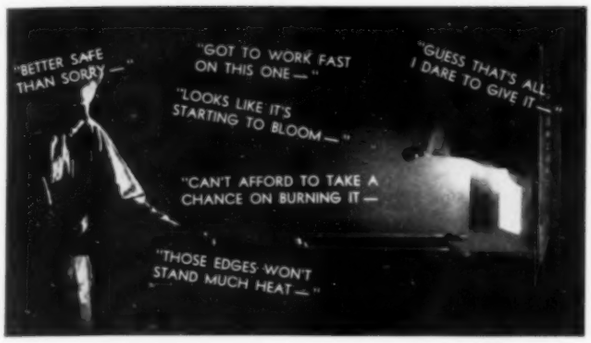
Besides revealing the flaws inside a piece of metal, as they do an abscess in a tooth, they are also used to examine solid manufactured objects for internal flaws, but that brings me up to consideration of the last and perhaps the most interesting wave lengths; namely, those called gamma rays. I will sketch for you briefly our own newly developed use for gamma rays before I close. I say "our" because the work was carried out by the writer a few years ago in collaboration with Robert F. Mehl and C. S. Barrett at the Naval Research Laboratory in Washington.

The preliminary reasoning which had led us to undertake our own particular experiments with the gamma rays was comparatively simple. We knew that X-rays would shine, if I may use that term "shine" for invisible rays, through a steel or aluminum object, and that if there were a cavity or flaw in the object, the rays would shine more intensely through the flaw than through the denser material adjacent to it. Where these more intense rays coming through the flaw fall upon the film placed behind, they produce a dark shadow.

But if a steel object were more than 4 in. thick, it took so long for the X-rays to blacken the film that the process was hopelessly slow and costly. Since many parts of machines, of battleships, of high pressure steam lines, and of other structures are more than 4 in. thick, this was a serious limitation to X-rays as a method of testing soundness. Imagine, if you will, a dentist telling you that he could X-ray your incisors but not your molars because they are too thick!

We also knew that the wave length of gamma rays was only about one-tenth that of X-rays, and that in general the shorter the rays the deeper they would penetrate. Therefore, we decided to try radiography by the shorter gamma rays, first under the most favorable circumstances and for thin objects, and finally for big objects of steel up to 6 or 8 in. thick, where X-rays would not effectively penetrate.

(Continued on page 100)


"BETTER SAFE THAN SORRY—"
"GOT TO WORK FAST ON THIS ONE—"
"GUESS THAT'S ALL I DARE TO GIVE IT—"
"LOOKS LIKE IT'S STARTING TO BLOOM—"
"CAN'T AFFORD TO TAKE A CHANCE ON BURNING IT—"
"THOSE EDGES WON'T STAND MUCH HEAT—"

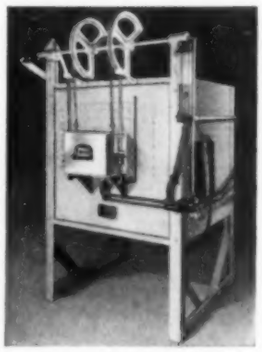
"We have no appreciable spoilage"

...yet they were sacrificing thousands of dollars to:

Spoilage Fear

A good hardener can avoid spoilage. But he can't avoid Spoilage Fear with a furnace where spoilage is just a few seconds away. He has to quench tools short of maximum red hardness. He has to work slowly and under constant strain. What happens when Spoilage Fear is removed? "Men using tools report 30% to 50% longer working life."—"Total savings amount to 25% of tool cost."—"Saving us $200 to $300 per month." THAT is what happens when Spoilage Fear is eliminated by the installation of "Certain Curtain" tool furnaces.

PRE-COMBUSTION DOES IT!



Our exclusive, patented Pre-combustion feature pre-combusts the furnace atmosphere outside the heating chamber and maintains any desired atmosphere in the heating chamber without fluctuation. As a result, even the most delicate tools can be held overtime at the critical without injury. The Certain Curtain margin-of-safety ELIMINATES Spoilage Fear.

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No! but *it does have instantaneous* photo-electric detection!

This modern TAG instrument gives new life to "on-off" 2-position and 3-position control! Unhampered by a chopper bar and galvanometer boom, and therefore controlling every instant, instead of through momentary contacts once in a while, its split-second action restricts overswing to the ultimate minimum.

A Beam of Light . . . A Mirror Galvanometer . . . A Phototube

This instrument indicates with a brilliant line of light which shows green, white or red for low, normal or high temperatures. It is visible at a great distance even in the dark. It is the ideal controller, not only for many industrial uses, but for a wide variety of laboratory purposes as well. Do you want to control to 0.1°-.01°-one microvolt? . . . Ask us about this, and send for the new 1937 TAG Pyrometer Catalog No. 1101B-76 today.

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In this connection Southwark may point to their close association with such eminent authorities as the directors of research of leading colleges and engineering schools, testing officials of many bureaus of the national, state and municipal governments, and prominent men engaged in the research laboratories of leading industrial plants.

Reflecting the influence of these "first minds" of the engineering world—Southwark testing machines and instruments always represent the most advanced thought in testing practice, meeting every up-to-the-minute routine or research testing requirement.

This is the reason why it would be difficult to find a modern testing laboratory today that is not using one or more types of Southwark Testing Equipment listed above.

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Pacific Coast Representative:
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SOUTHWARK

Invisible rays

(Begins on page 56)

I suppose we would have used cosmic rays if we could have controlled them!

None of us had ever handled or used radium before. In fact, I do not think any of us had ever seen it. But we **had** read about it and we knew that the gamma rays which it sends out without pause during millions of years were of the same general nature as X-rays, that is, they were electromagnetic waves. We believed we could make them serve mankind in a new way, namely, in the testing of metals.

The Navy Department, under whose auspices this work was done, rented for us 200 millicuries of emanation (equivalent to 1/5 g. of radium) and a messenger went to the Kelly Hospital in Baltimore to bring it back, while we were busy putting films into black enevlopes (they had to be black to keep out the invisible light) and tying them to the backs of the objects we were preparing to examine in the first experimental trial. The experimental arrangement consisted of a table with movable wooden upright pieces for supporting the test objects, with a film behind each object. A tiny funnel was erected in the center of the table to receive the radium capsule. Our precautions for personal safety were made with great care, as we were adventuring for the first time upon ground unknown to us and there was no point in taking unnecessary risk. As soon as the last mechanic had left the shop in the evening, the radium capsule was brought in from a nearby field, where it rested in a lead-lined box about as large as your hand; dropped into the thistle tube in the center of the circle of objects to be tested and we all went home leaving the radium there all night to do its work.

You may be sure that it was with the utmost expectancy that we moved the capsule next morning back to its lead box and sent the films to be developed. The smile on the face of the operator as he brought the first one out of the dark room was reassuring, and examination of the film itself a moment later seemed to justify our highest hopes as to the success of the method, not only in showing all flaws inside the test objects, but in showing them sharply and distinctly. Because of its historical interest, I show this film on page 60—a monkey wrench with the wooden handle and metal parts appearing almost as translucent as thin chinaware.

As the development of the method proceeded, we found that it possessed advantages that we did not expect. For example, it not only penetrated 12 in. of solid steel, but it registered clearly and with almost none of the haziness which is charac-

(Continued on page 104)

R·C BLOWERS
and GAS PUMPS for
DEPENDABLE
FURNACE OPERATION

Air and gas in proper proportions and under the right pressures are important when furnace temperatures must be quickly attained and accurately controlled. Supplying the air and boosting the gas pressure, when needed, are jobs "R-C" Blowers and Gas Pumps do well.

"Tomorrow's Engineering Approved by Yesterday's Experience"

Manufacturing both positive displacement and centrifugal types permits us to recommend the best unit for your particular requirements. Our experience is yours to command. Make use of it.

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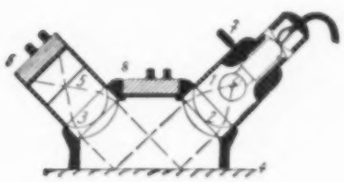

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Price, with photo-element, micro-ammeter with 2 built-in variable resistances, spare bulbs.....$125

Gloss Meter, as above, but without micro-ammeter $60

Particulars on request

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EMPIRE STATE BUILDING, NEW YORK

DIAMO-BRINELL
Hardness Testing Machine

The Most Accurate Apparatus for Testing All Kinds of Metal.

The Brinell method of testing is followed in this *Diamo-Brinell Tester*. The indenter is a pyramid-shaped diamond instead of a steel ball generally used. Result: impressions are square and well-defined—exact measurements can be taken.

The desired load is applied by a system of weights and levers. Time of load application is mechanically controlled—always the same.

Try this tester for hard or soft metals, also for very thin material. You can depend on its accuracy. Remember, too, we build testing machines to meet your special requirements.

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Silver Solder

Characteristics and uses of 12 standard compositions of silver solders meeting almost all requirements for this useful material are described in a folder by Handy & Harman, Inc. Bulletin Aa-126.

Carburizing Steel

Union Hymo is a carburizing steel especially adaptable to gears and shafts and other parts requiring high wear resistance. Its special properties and applications are described in a folder by Union Drawn Steel Co. Bulletin Aa-83.

Tube Furnaces

The uses, construction, control and operation of combustion tube furnaces are given in a folder by Hevi Duty Electric Co. which includes complete specifications for various types. Bulletin Aa-44.

Constructional Steels

A reprint of a technical article by E. C. Smith, chief metallurgist of Republic Steel Corp., on "The Making and Shaping of Alloy Constructional Steel" is prepared for distribution by International Nickel Co. Bulletin Aa-45.

Thermometers

A 72-page catalog by Brown Instrument Co. covers the complete line of Brown thermometers and pressure gages—indicating, recording and controlling—and enumerates the wide range of industries to which they are applicable. Bulletin Aa-3.

Steel Service

"Steel Service" is the title of a bulletin which gives valuable information on testing methods and pickling control charts. It is distributed by the Grasselli Chemicals Department of E. I. du Pont de Nemours & Co. Bulletin Aa-29.

Liquitol

The use of Liquitol for controlled cooling of iron and steel castings and ingots is fully described in a bulletin by Alpha-Lux Co., Inc. Bulletin Mya-120.

Muffle Gas Furnaces

Two models of Juthe muffle type gas furnaces for pre-heating, hardening and annealing, and for heat treating high speed steel are described in bulletins by American Electric Furnace Co. Bulletin Aa-2.

Cr Stainless Steels

Complete information attractively presented on Enduro AA, S, S-1, and FC is contained in a booklet by Republic Steel Corp. Enduro AA is the 18% Cr steel, and S, S-1 and FC are of the 11 to 16% Cr type. Bulletin Aa-8.

Coordinated Control

A new system, known as the Coordinated Control System, for automatically operating all of the technical operations and factors of an industrial process is described by the Bristol Co. Bulletin Aa-87.

Oven Furnaces

In a nutshell American Gas Furnace Co.'s improved oven furnaces offer controlled atmosphere, quiet operation, economy, are over and under-fired and bottom vented. Described more fully in Bulletin Aa-11.

Spoilage Fear

Fear of spoilage, says C. I. Hayes, Inc., may cost a firm more than actual tool loss through spoilage in the furnace. How "certain curtain" furnaces eliminate spoilage and spoilage fear is told in Bulletin Aa-15.

Electric Control

A complete new control system for regulating input in proportion to demand is described in "Micromax Electric Control," an illustrated eight-page catalog issued by Leeds & Northrup Co. Bulletin Oy-46.

Blowers

A folder devoted to the application of rotary positive blowers in foundry cupola service, issued by Roots-Connersville Blower Corp., discusses in detail the structural and operating features of these blowers. Bulletin Jyc-131.

Torsion Impact

Baldwin-Southwark Corp. makes available a folder of technical information on their Carpenter torsion impact testing machine, showing how to operate it and indicating the types of investigation the machine will serve. Bulletin Ob-67.

Electric Heat

The certainty of results obtained with electric heat is economically available in automatically controlled electric furnaces. Hoskins Mfg. Co. has a catalog stressing the advantages and low-cost maintenance of their line of furnaces. Bulletin Jya-24.

Air-Clutch Forgings

Two bulletins are offered by Ajax Mfg. Co. One tells about their air-clutch forging machines in 2- to 7-in. sizes, made according to the most advanced design. The second is concerned with the Ajax-Hogue wire drawer, an attachment for heading machines which presents new economies. Bulletin Ox-105.

Drop Forgings

An attractive and comprehensive book on drop forgings has just been published by the Drop Forging Association. The book deals with the characteristics, qualities and uses of drop forgings and is a valuable addition to the library of any one interested in this subject. Bulletin Aya-123.

Mo-Cr-Ni Forgings

A real text is presented by A. Finkl & Sons Co. on heat treated molybdenum-chromium-nickel steel forgings for heavy machinery. The illustrations and physical property tables and curves speak for themselves. Bulletin Mya-23.

Liquid Carburizing

E. F. Houghton's Perliton liquid carburizer is the subject of a 23-page booklet. Depth of case, speed of penetration, and other results are well illustrated with graphs and photomicrographs. Bulletin Nv-38.

Screw Machining

Screw machine products of aluminum are treated in authoritative and extensive manner in a booklet of Aluminum Co. of America. Besides general data on screw machining, a number of very useful tables appear. Bulletin Ar-54.

Spectrographs

A new catalog has been prepared which gives complete details of the Bausch & Lomb line of spectrographs and accessories, from small units to the large Littrow spectrographs with "matched" accessories, to satisfy the most exacting needs. Bulletin Aya-35.

Heat in Industry

"Wherever Heat Is Used in Industry" is the title of Surface Combustion Corp.'s new booklet which starts with "Surface Combustion" principles and shows a part of various types of standard burners and furnaces and special furnaces. Bulletin Dx-51.

Electric Salt Baths

Literature is available from Bellis Heat Treating Co. describing electrically heated bath furnaces which are economical to operate and have a wide range of applications in hardening, annealing, and heat treatment of high speed steel, stainless steel, nickel, aluminum, copper and bronze, etc. Bulletin Ny-48.

Foundry Metallograph

Today's engineering cast irons are structure-controlled in the foundry. The E. Leitz simplified micrometallograph MM-2 is particularly adapted to foundry applications. Bulletin Fy-47.

Ferro-Alloys

An interesting folder by Electro Metallurgical Co. tells all about their ferro-alloys and their special service to users which will help them to operate their furnaces and make alloy additions under the proper conditions. Bulletin Jya-16.

Steel Handbook

A handbook has been prepared by Heppenstall Co. covering the effects of alloying elements and the physical properties of steel in forged sections. Such valuable data as heat treating definitions, McQuaid-Ehn grain size classification, hardness conversion tables, and physical property tables are included. Bulletin Jyb-122.

Tempering Furnace

Technical details and operating data on Lindberg Steel Treating Co.'s new Cyclone electric tempering furnace, which has shown a remarkable performance record in steel treating operations, are given in Bulletin Fx-66.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in Bulletin D-17.

Ni-Cr Castings

Compositions, properties, and uses of the high nickel-chromium castings made by The Electro Alloys Co. for heat, corrosion and abrasion resistance are concisely stated in a handy illustrated booklet. Bulletin Fx-32.

Alloy Castings

Michiana Products Corp. has published a new book describing Michiana corrosion resistant and stainless steel alloys. Generously illustrated, it suggests many savings for the use of these alloys. Bulletin Oy-81.

Testing with Monotron

Shore Instrument & Mfg. Co. offers a new bulletin on Monotron hardness testing machines which function quickly and accurately under all conditions of practice. Bulletin Je-33.

Newer Tool Steels

Vulcan Crucible Steel Co. has a complete and attractive catalog listing their full line of tool steels including many special types to meet the modern trends in industry. Bulletin Jyb-127.

Some of the Best Thinking

in the metal industries is at your disposal in the literature described here. One booklet may hold the key to your current problem. Help yourself to this helpful literature. It's free. You incur no obligation when you return the coupon.

Compressor Data

General information on the application of blowers to gas and oil burners, and miscellaneous applications for other types of work are included in a 12-page "Turbo Compressor Data Book." Useful tables and charts are included. Spencer Turbine Co. Bulletin Dy-70.

Chain

Interesting information on chain and belt conveyors for use at high temperature may be had by sending for a new illustrated bulletin by Michigan Steel Casting Co. Bulletin Dy-84.

Bright Annealing

Electric Furnace Co. tells about their controlled atmosphere furnaces for continuous deoxidize annealing, bright normalizing and annealing ferrous and non-ferrous metals. Work comes clean, bright and dry from these furnaces. Bulletin No-30.

Laboratory Service

A new edition of "The Metal Analyist" tells about an organization established by Adolph I. Buehler specializing in the installation of metallurgical laboratories. The complete line of laboratory equipment marketed by Buehler is also catalogued. Bulletin Dy-135.

Forging Experience

The experience of 21 years has made National Forge and Ordnance Co. the headquarters for a host of basic electric steel products. Typical products and equipment for making them are described in a series of attractive pictorial circulars. Bulletin Dy-136.

Stainless Data Book

All users of stainless and heat resisting alloys should find invaluable the information contained in a booklet published by Maurath, Inc. giving complete analyses of the alloys produced by the different manufacturers, along with the proper electrodes for welding each of them. Bulletin Jyb-125.

Locomotive Steels

A comprehensive review covers specific applications, based on current practice, of various types of vanadium steels for locomotive and car construction. It contains 72 pages and is available to railway executives and engineers. Published by Vanadium Corp. of America. Bulletin Dy-27.

Machining Stainless

Don't let machining problems keep you from using stainless steel. A booklet by U. S. Steel Corp. contains full information on two types of stainless steels which can be easily handled on automatic screw machines for quantity production. Bulletin Ny-79.

Silmo Steel

A series of six loose-leaf pages is available from Timken Steel & Tube Co. which gives complete physical data on "Silmo," a new steel especially designed for applications where an economical combination of high temperature strength and oxidation resistance is required. Bulletin Dy-71.

Camera-Microscope

A highly efficient and up-to-date apparatus that is an ingenious combination of several instruments into one universal camera-microscope is described by Pfaltz & Bauer, Inc. in a handsomely printed booklet containing some intriguing photomicrographs. Bulletin Oy-142.

Light Case

Severe breakdown tests were run by A. F. Holden Co. to study the characteristics of Holden Light Case in relation to case penetration and the total change of chemistry of the bath. They are described, and a chart showing results is reproduced, in a folder ready for distribution. Bulletin Dy-55.

Nichrome

"Nichrome" nickel-chromium resistance alloy is not the only product made by Driver-Harris Co. A new 68-page catalog gives complete data for this well-known material as well as a wide variety of other alloys. Bulletin Oy-19.

Rotoblast

A new blast cleaning machine eliminates the need for compressed air as the abrasive driving agent. Pangborn Corporation tells how a rapidly spinning wheel propels the abrasive by controlled centrifugal force. Bulletin Ox-68.

Rustproofing

How the Detrex method of solvent degreasing provides the advantages of speed, economy, and satisfactory cleaning before all kinds of rustproofing and finishing operations is pointed out in a leaflet by Detroit Rex Products Co. Bulletin Dy-111.

Recuperators

Results obtained with Carborundum Company's recuperators using Carbofrax tubes are fuel savings, closer temperature control, faster heating, and improved furnace atmosphere. Complete engineering data are given in Bulletin Fx-57.

Heat Treating Manual

A folder of Chicago Flexible Shaft Co. contains conveniently arranged information on heat treating equipment for schools, laboratories and shops, and also illustrates the several types of Stewart industrial furnaces. Bulletin Ar-48.

Port Valves

Diagrams and descriptive matter show the operation of adjustable port valves made by North American Mfg. Co. that are particularly suitable for mediums whose rate of flow is not constant. Bulletin Oy-138.

Capacitrol

An indicating control pyrometer is made by Wheelco Instruments Co., known as the Wheelco Capacitrol. Their bulletin gives full description, wiring diagrams for different furnace or oven installations, and price. Bulletin Mya-110.

Cutting Steel

Recommended practices for gas cutting of structural steel are given in a concise and authoritative form by The Linde Air Products Co. Qualification tests for good workmanship from the standpoint of accuracy and smoothness of cuts are also described. Bulletin Dc-63.

New-Series Recorders

Foxboro's new bulletin describes in detail the extra, compensating slide-wire — a feature found only in the Foxboro potentiometer recording pyrometers for industrial temperatures. All types are listed and illustrated in this booklet. Bulletin Myb-21.

New Recorder

C. J. Tagliabue Mfg. Co. announces for the first time in a new edition of their pyrometer catalog a new two- and three-position recorder-controller. The complete Tag line of indicating, recording, and controlling pyrometers, which utilize a beam of light, a mirror galvanometer and a phototube, is also described. Bulletin Ay-62.

Pure Metals

Pure, carbide-free metals are described and applications suggested in a pamphlet published by Metal & Thermit Corp., who make pure tungsten, chromium and manganese in addition to the ferro-alloys. Bulletin Myc-64.

Specialized Tester

The Rockwell superficial hardness tester is a specialized instrument for use where the indentation into the work must be kept shallow or of small area, yet sensitivity preserved. A supplement to Wilson Mechanical Instrument Co.'s catalog on the regular Rockwell tester tells all about it. Bulletin Sy-22.

Nickel-Copper Steels

Exceptional resistance to corrosion and abrasion, increased tensile strength, and higher ductility are the qualities claimed for Youngstown Sheet & Tube Co.'s new series of Yoloy steels. A summary of properties and notes on their characteristics are contained in Bulletin Ox-93.

Moly Cast Iron

The use of molybdenum in foundry practice, both on steel and cast iron, is described in a handsome booklet by Climax Molybdenum Co., which presents accurate technical information in a striking and modern manner. Bulletin Jyc-4.

Cutting Oils

The problems of machine tool lubrication engendered by the high speed production and close tolerances of modern industrial operations are discussed and progress in cutting oils during the past few years reviewed in a booklet by D. A. Stuart & Co. Bulletin Jyb-118.

Tocco Process

This amazing new and extremely accurate method of heat treating is described in a new four-page leaflet, yours for the asking. Distributed by Ohio Crankshaft Co. Bulletin Oy-145.

Corrugated Ingots

The Gathmann Engineering Co. has published a new booklet called "Gathmann Ingot Molds — Their Purpose and Design." It illustrates various corrugated ingot contours designed to produce defect-free surface in steel ingots. Bulletin Aya-13.

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Invisible rays

(Begins on page 56)

teristic of X-ray films when not specially protected against scattering. It was far simpler than an X-ray equipment to maintain and operate, and it was entirely portable, the radium being only the size of a 22-caliber cartridge.

As to practical applications of the gamma ray method, I might cite the examination of a keel knuckle casting of one of the new 10,000-ton cruisers. Cracks had appeared on the surface of this casting, had been chipped out and welded by the electric arc. To test it, films were placed on the area and a radium capsule was positioned behind the section, and found an internal crack at a point where the steel was 6 in. thick!

Since radium radiates in all 360° of solid angle, it "broadcasts" its rays, so to speak. Objects to be tested may therefore be grouped about it, not only in a complete circle, but in a complete sphere. The view on page 60 shows the simplicity with which an entire circumference of a cylinder (in this case a gun slide of the U. S. Navy's) may be exposed at one time. The radium is placed at the axis of the cylinder and several complete circles of film outside.

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UNITED STATES STEEL

By A. L. Boegehold
Metallurgist, Research Laboratories
General Motors Corp.

Plain carbon steel its utility for automobiles

IN RELEASING the new list of 109 S.A.E. steels in April 1935, Frank P. Gilligan, chairman of the standards committee of the Society of Automotive Engineers and past president ⊕, took note of the frequently heard criticism "There are too many steels included in the S.A.E. specifications," but defended the committee's action on the basis that enough information was not available either to the producer or user of the steels to warrant simplification of the list, desirable though that might be. The present writer served on Mr. Gilligan's committee, and is one of those who believes we have entirely too many steels, and that a large number of them could be consigned to oblivion without ever causing hardship to any metallurgist or engineer.

Of course, one cannot go too far even in that direction. It would be delightfully simple if we could use for all machine parts a simple series of steels varying in carbon content depending upon the strength desired. Unfortunately the mass of differing requirements which must be met by the various parts of an automobile (and to a corresponding degree by other machine parts) makes any such simple solution impossible. In this discussion — part of a talk for the Saginaw Valley Group, ⊕ — an endeavor will be made to explain why this is so.

The automobile is made up of a multitude of parts of various shapes and sizes. The services performed by all these parts are many and complex. It is the duty of the metallurgist to select steels and heat treatments for those parts so they will function satisfactorily and continue to do so for years of punishing operation. In addition, this result must be obtained with the least possible cost. This means that all operations involved in manufacturing the part must be performed on the steel with the utmost facility. This brings in many properties for consideration besides the tensile strength and other commonly determined mechanical properties, and among these properties to be considered from the manufacturing standpoint are machinability, response to normalizing or annealing, reaction to pickling, freedom from occasional seams or excessive slag and other unsoundness, ease of shearing, hardenability, distortion tendencies, and type of heat treatment required to get the properties desired.

The most important requirement, however, is that the steels selected must be capable of developing the properties demanded by the engineering requirements of the parts in use. This phase of the subject will form the principal part of the ensuing discussion.

One phase of the problem of too many steels, stated at the outset, is contained in another question: "Why do we have to use alloy steel at all; why not build the whole car out of carbon steel?" Upon superficial examination of physical properties of heat treated steels this might appear feasible. For example, the curves on page 148 show the tensile strengths as plotted against Brinell hardness for a number of commonly used plain carbon and alloy steels. So far as strength is concerned the plain carbon steels appear to be just as satisfactory as the alloy steels.

General use of carbon steels is prevented, however, by certain serious limitations:

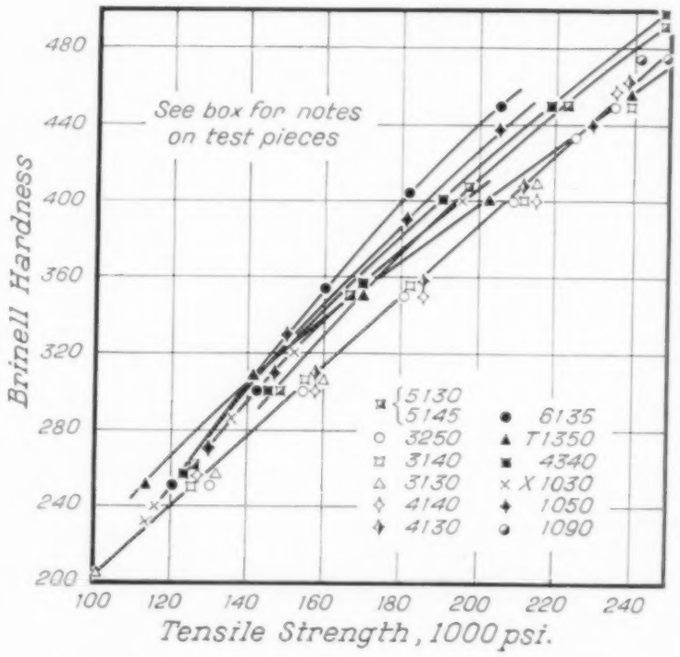
1. They require fairly rapid cooling from above the critical to harden; consequently high strength can only be obtained in light sections, for only light sections can be cooled rapidly enough to harden throughout.

2. Even in light sections where high strength *can* be developed, ductility is lacking — possibly because of residual stresses from rapid quenching — with the result that stress concentration at notches and grooves is greater than in alloy steels.

We believe that a considerable amount of ductility combined with high strength is desirable in those machine parts whose shape is such that stresses are concentrated at notches or projections. Few stresses as applied in service are quiescent — they vary in intensity and in speed of application. Hence the desirability of *toughness* to afford a means of stress redistribution at points of stress concentration. We must therefore examine the relative merits of carbon and alloy steels in these respects.

In a 1930 report of the A.S.T.M. research committee on fatigue of metals, H. W. Gillett stated that a strong, brittle steel acts just like an equally strong, ductile steel when in endurance tests on small specimens. He, however, referred to smooth test pieces. In articles or specimens having notches, projections or other conformations causing stress concentration — or even minor imperfections or inclusions at or near the surface of the steel — ductile materials undergo sufficient local deformation at these places to cause stress redistribution, so that stress concentration is considerably less in them than in brittle materials where this deformation and redistribution cannot take place without rupture.

Any user of steel does not need a definition of the word "brittle." However, testing engineers have not yet been able to agree on a method of measuring this property quantitatively. It is the converse of toughness, the ability to absorb punishment, and toughness (a qualitative term also) has a general relationship to ability to deform before rupture. The latter property is measured by the reduction of area in a tensile test. The second set of curves therefore gives information about the tensile strength and ductility of the steels shown in the first figure. The striking fact observed in this second chart is how little ductility is possessed by the plain carbon steels at the higher strengths compared with the alloy steels. The 4130 chromium-molybdenum steel has the highest ductility; however, the samples used for these tests were water quenched so the values plotted here are not strictly comparable with other alloy steels that should be oil quenched. It is remarkable how the ductility of the 4340 chromium-nickel-molybdenum steel is maintained at the higher strengths above 250,000 psi.



When Ultimate Tensile Strength Is Plotted Against Brinell Hardness It Seems That Carbon and Alloy Steels (in Small Sections) Are Not Greatly Different. Ductility is another matter—see diagram on next page

For parts that are required to have not more than a strength of 150,000 psi., — that is, up to about 340 Brinell — a plain carbon steel would be perfectly satisfactory, *if* the parts were small enough so they would be properly hardened without such drastic quenching as to form cracks or cause too much distortion, and *except* for the fact that plain carbon steel above 300 Brinell is looked upon with decided disfavor by those in the manufacturing departments who have to do the machining. It is not customary, therefore, to use plain carbon steel over about 286 Brinell in parts that have to be machined after heat treating. On the other hand, parts that are light enough to be hardened satisfactorily, are not machined after heat treating, and are subjected to simple stresses without any stress concentrations — such parts may be made

from plain carbon steel with complete success. Coil and leaf springs are good examples of parts conforming to these requirements.

Valve springs are almost always made of S.A.E. 1065 steel and leaf springs are made in large numbers from S.A.E. 1085 and S.A.E. 1095 steels, all plain carbon. These springs are used in a condition where they have a hardness range near 400 Brinell and strength at about 200,000 psi. Being of simple shape without grooves, notches or other forms that would cause stress concentration, these parts do not need to have very much ductility to endure the high stresses to which they are subjected.

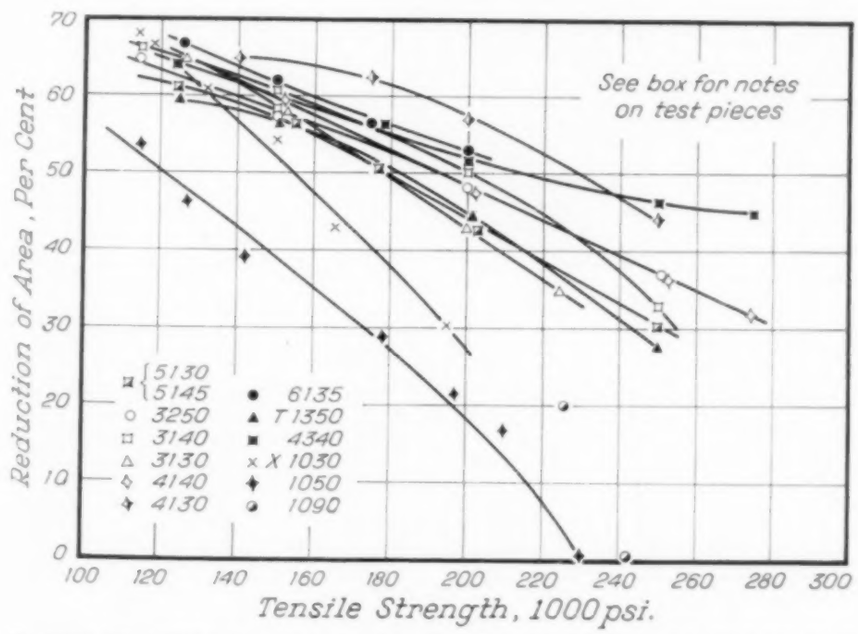
Certain parts in the power transmitting system have functions of such a nature that one of their principal requirements is stiffness; bending or twisting must be maintained at a minimum. Crankshafts and connecting rods are examples. Since all steels have the same modulus of elasticity (or ratio of load to deformation caused thereby, that is to say, "stiffness"), the only way that rigidity can be obtained in such parts is to keep stresses low by increasing the size or outside dimensions of the part. The efficient way to get the most rigidity with the least amount of metal is to distribute the metal as far as possible from the neutral bending axis of the piece — in other words, so that the moment of inertia of the cross-section of the member is high. When done efficiently, this results in low unit stresses even though the total loads imposed are high.

Tests shown in the two diagrams on these pages were all made on heat treated 1-in. rounds, except X1030, 1050 and 1090, which were made on heat treated 0.510-in. specimens, and except 4130, which were heat treated 1.33-in. rounds. All specimens oil quenched except S. A. E. 4130 and X1030, which were water quenched

Crankshafts and connecting rods are usually not required to have more than 130,000 to 140,000 psi. tensile strength, with a minimum of 100,000 psi. for crankshafts and as low as 75,000 psi. for connecting rods. Some connecting rods, due to extra high loads, require strength up to 150,000 psi., or a hardness in the neighborhood of 300 Brinell. For this and other reasons, plain carbon steels are perfectly satisfactory for connecting rods. In the range of hardness used they machine well and have adequate ductility. The sections are usually such that plain carbon steels harden fully when oil quenched or, if necessary, water quenched. When water quenching, a fine-grained steel is secured to guard against cracking.

Some connecting rods are made from a free cutting, medium manganese steel (S.A.E. X1335, in the normalized condition). This is purely to gain a cost advantage by spending a very little more for the steel in order to eliminate part of the heat treatment cost, and the cost of straightening plain carbon parts distorted in the hardening operation.

For crankshafts, S.A.E. 1045 plain carbon steel is almost universally used. On account of the thickness of section, they must be water quenched; even then only the outside layer is fully hardened. Free ferrite may be observed in the micro-



Ductility (Reduction of Area in the Tension Test) Is Very Much Higher for Alloy Steels Than for Carbon Steels When Heat Treated to Equal Strength and Hardness

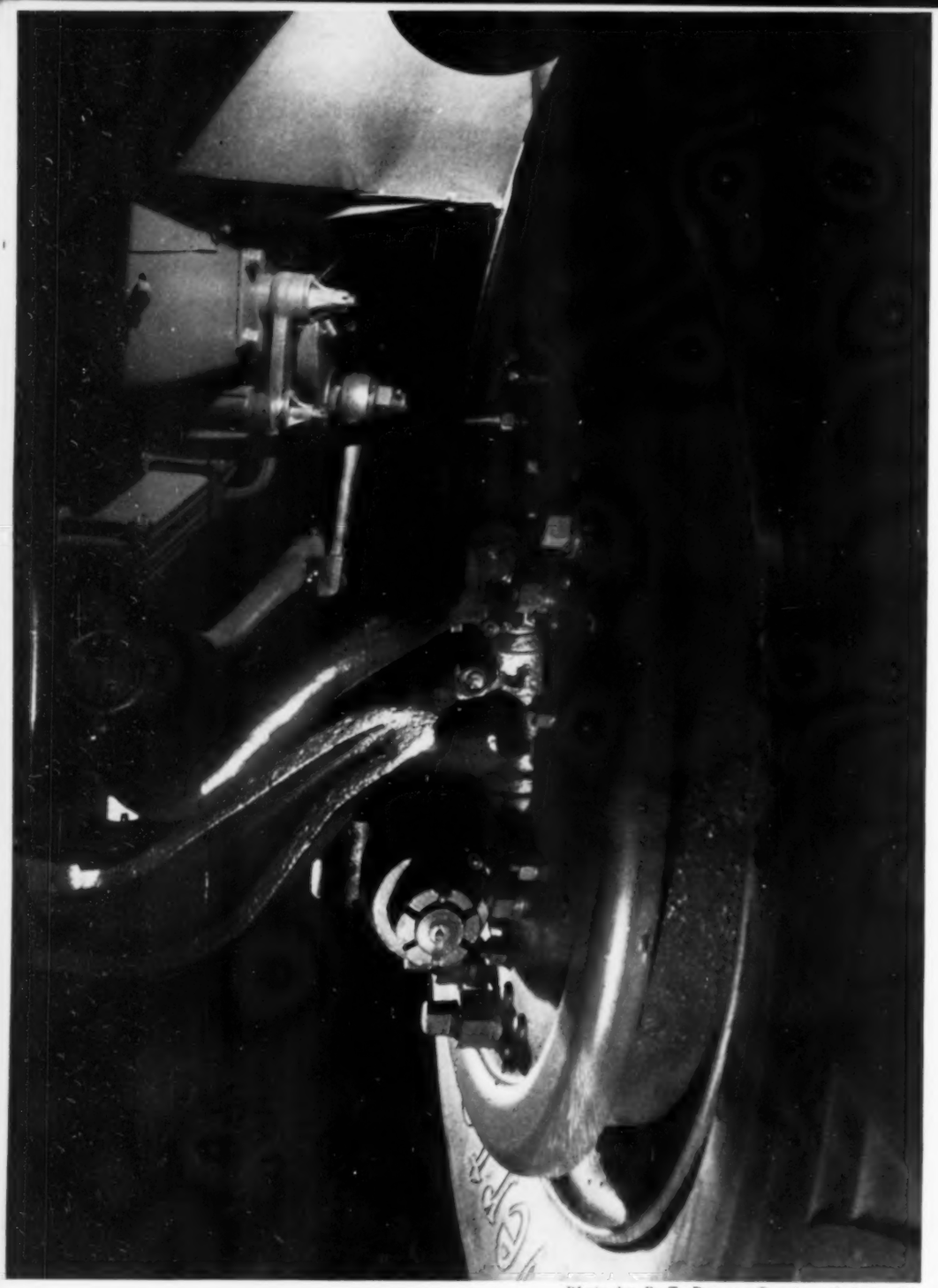


Photo by R. T. Dooner, Courtesy Autocar Co.

Highly Stressed Automotive Parts Made of Plain Carbon Steel Include Axles and Springs, Particularly Coil Springs

structure as near to the surface as ¼ in. The shaft is then tempered to a hardness between 229 and 269 Brinell, in which condition it is readily machinable. A comparatively recent advance in the manufacture of crankshafts is local hardening of the crank pin surface and the main bearing journal by inductive heating by electricity. Such hardened rubbing surfaces have become desirable to prolong the life of the part. The fact that normalized X1050 steel containing 0.25% chromium is being successfully used for crankshafts, in connection with the induction hardening of the crank pin and main bearing journals, shows how low the stresses are in this part.

Plain carbon steel, carburized and quenched in water, brine or caustic to very high surface hardness, is well adapted to a number of parts of cylindrical shape either hollow or solid. Some of the parts in this class are the reverse idler gear shaft, the counter gear shaft, the piston pin, the water pump shaft and the camshaft. The hard surface obtained in this way cannot be excelled for wear by the more expensive alloy steels. Free machining steels are used for some of these parts and given the same kind of hardening treatment. We have evidence from both static and fatigue tests that a plain carbon steel, carburized and hardened, is not as strong as even the cheaper alloy steels, and is considerably weaker than the nickel steels (like S.A.E. 2315, 4615 or 4815) carburized and hardened. Nevertheless, the diameter of these cylindrical parts is such that the 1020 plain carbon steel is amply strong when carburized and hardened. If an attempt were made to take advantage of the higher strength of the alloy steels by reducing the diameter of these shafts, it would be found that the increased stresses would impose excessive deflections which would interfere with the satisfactory performance of the mechanism. Here again is a case where the governing requirement is *stiffness* and because of this, the stresses in a part that is stiff enough are low enough to permit the use of a low cost steel. All these parts are ground all over after heat treatment; consequently any distortion as a result of the drastic quench is of no consequence.

In the case of the piston pin there may be considerable variation in the load imposed, depending upon whether the small end of the connecting rod is clamped onto it, or whether it floats, or whether cast iron or aluminum pistons are used. The maximum rotational speed of the engine also has an effect. In some cases it has been found necessary to use something stronger than S.A.E. X1020 or 1115. Medium manganese free-cutting X1314, nickel-molybdenum 4615 and chromium steel S.A.E. 5115 are typical of those which are also used in piston pins.

Carbon Steel for Crankshafts

The camshaft is another part admirably suited for plain carbon steel. The loading is low, there are no stress concentrations, and it is of a size that can be readily hardened. Only the cams are carburized, as a general rule. Recently the camshaft is being carburized all over in some plants; quenching in a fixture eliminates straightening. In this practice the shaft is water quenched in order to obtain an extremely hard surface to resist wear from contact with the tappet, and wear on the gear that drives the distributor gear.

The coil spring for the individually suspended front wheels in the "knee action" is an interesting metallurgical study because of the high stresses induced from the loads imposed. When the wheel moves upward to the bump position the stress in a typical spring is 117,000 psi. in torsion — almost up to the elastic limit. Naturally, considerable movement accompanies this stress. There are no other parts of the car stressed as highly as the springs and we can rest assured that there probably never will be, because with that amount of stress there is also a proportionate deflection. It is quite obvious that we would be unable to tolerate deflections in our other operating parts of the same order as experienced in the springs.

Any part stressed as near to its elastic limit as a spring is, must not have any surface irregularities to cause stress concentrations. This is responsible for several interesting features associated with the manufacture of coil springs; some of them are clearly shown in the pictorial story starting on page 163 of this issue. First, the steel rod is ground to remove all decarburization. It is then heated for coiling, the temperature being held down around 1450 to 1500° F. to be sure that no decarburization occurs in this operation. This is very important, because

Heat Treated Carbon Steel Is Also Amply Good in Its Properties for Crankshafts, Even for Most Severe Duty

a spring decarburized a few thousandths of an inch at the surface will take a gradual and continuous set in service and will have a short life when failure occurs. A consideration of the properties of the decarburized surface layer will readily explain why this is so; it has a strength of only 45,000 to 50,000 psi. in tension, or 60% of that figure in torsion. When this surface metal (which receives the maximum stress) is subjected to 117,000 psi. torsional stress repeatedly in going over the bumps, there is bound to be a fatigue crack develop which travels inwards to the depth of the decarburized layer. This crack then acts as a notch to cause stress concentration, which results in overloading and cracking the full-strength material immediately under the decarburized layer.

A properly processed spring will have, as one of the manufacturing operations, a "setting down" which consists of closing the spring several times until it takes a slight permanent set. Unless this is done even a properly heat treated spring will take a permanent set in service. In addition to this, springs are sometimes shot blasted to cold work the surface slightly. This not only obliterates any surface imperfections which might have acted as stress raisers

but by cold work it also increases the strength of the surface layer and prolongs the life.

These coil springs are often made of silicon-manganese steel, S.A.E. 9260, heat treated to a Brinell hardness of 429 to 477; plain carbon 1085 steel has also been used successfully for this suspension. This again is evidence that plain carbon steels may be used under highly stressed conditions providing the section is small enough so that complete hardening is obtained without resorting to such drastic quenching that there is danger of cracking, and also providing that the article made from plain carbon steel is of such design that there are no stress concentrations.

There are, to be sure, cases where plain carbon steel is used where stress concentrations occur, but the calculated stress on these parts is low enough so that the true maximum at sharp corners or grooves is well within the endurance limit. An example of this kind is observed in the case of differential side gears and differential pinions. The shape of a gear with its projecting teeth with the possibility of sharp corners and tool marks at the roots of the teeth presents a picture of considerable stress concentration, and any time plain carbon steels are *successfully* used in these parts in a modern high-powered automobile, we can be sure that a good job of engineering has been done!

Resumé of Limitations

There are some other minor parts made from plain carbon steel, heat treated, but the foregoing illustrates the principles governing the successful use of plain carbon steel in important machine parts. Briefly they are as follows:

(a) The part must be small enough so that it will harden completely without too drastic a quench.

(b) The part must be fairly regular in cross-section so that it can be heat treated without warping beyond the possibility of minor straightening.

(c) The part requires so much stiffness that it is bulky and the metal is lightly stressed.

(d) The shape must be free from notches, grooves and any other stress raisers at all critical locations.

To state these limitations is to define the true field of heat treated alloy steels. This, however, will be discussed at length in a second article, to appear next month.

Veining and mosaic structure in metals

By L. Northcott
Research Dept., Woolwich Arsenal

Condensed from The Metallurgist, Oct. 30, p. 165, and Dec. 25, 1936, p. 184

FERRITE, either in electrolytic iron, ingot iron, wrought iron or low carbon steel (as well as many another metallic crystal) sometimes reveals within the grains a network, ordinarily termed "veining." Recent investigations by the present author, published in *Journal* Iron & Steel Institute, 1932, II, p. 267, and *Journal* Institute of Metals, July 1936, have shown this structure to be associated with the precipitation, from solid solution, of small quantities of oxides whose solubility in the metal decreases with decrease in temperature. At all temperatures the quantitative solid solubility is very, very small, but is sufficiently less at atmospheric than it is at elevated temperatures to permit the excess oxide to be precipitated from solution in the form of a network at certain rates of cooling. Excessively slow cooling favors coalescence, and the optimum cooling rate for the development of a network structure has been found to vary appreciably for a number of different alloys.

The second paper quoted above distinguishes between veining and sub-boundary structures, the latter referring to a precipitate, also occurring in a network form, of a constituent of the alloy other than oxide. The mode of formation of both networks is the same and only the nature of the precipitate is different. Treatment in a reducing atmosphere at high temperatures is without effect upon the sub-boundary structures, but removes veining from the surface layers except in alloys containing aluminum or silicon whose oxides are known aot to be reduced except at very high temperatures.

It is now desirable to consider whether the precipitates which cause veining and sub-boundary structures are located by the so-called "mosaic," "block," "lineage" or "secondary structure" which physicists and crystallographers have postulated. With the one exception to be discussed immediately, the existence of such sub-structures would appear to rest upon exceptionally slender experimental evidence.

(Continued on page 208)

The spring washer—a modest but essential part

By Chandler C. Washer
Assistant to President
Philadelphia Steel & Wire Corp.

A NUMBER of interesting articles have appeared in METAL PROGRESS during the last year describing the various steels used to manufacture automobile parts and explaining the processes of heat treating such parts to insure the desired performance in service. Yet if a list were made of the different components requiring heat treatment, it is quite likely that one item would be entirely forgotten, or considered last. That item is spring washers, of which approximately 800 are used in each automobile. A similarly important consumption of this modest but essential part could be discovered in every machine.

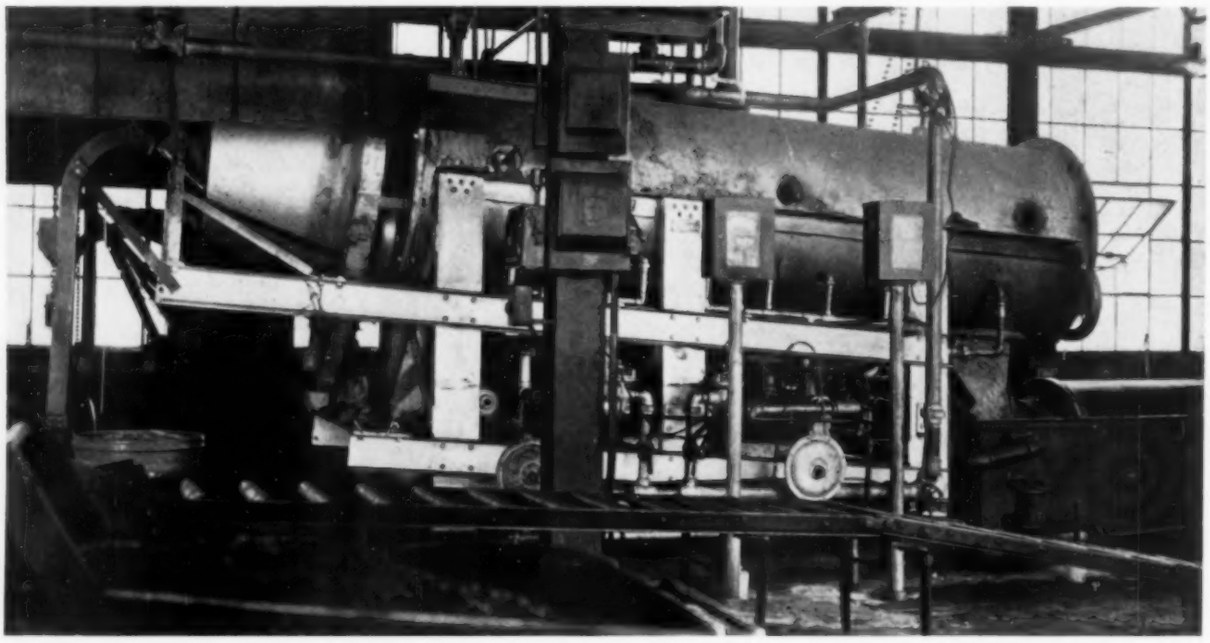
Perhaps the vital importance of proper heat treatment, scientifically applied, is as well exemplified in the manufacture of spring washers as in the making of any other part of spring steel. Among a large percentage of technical men, the words "heat treatment" immediately suggest "automobile." The reason for this is that the automobile industry was the first to utilize the art in a large way for anything but tools (or arms and armor) and as the automobile increased in speed and reliability and decreased in weight, more and more demand was made upon the metallurgist for better and more reliable steels. The selection of a steel for a definite application in an automobile is not complete until its best treatment is determined.

Due to the large quantity of individual items made and heat treated for use in our many low-priced automobiles, special furnaces have been developed for certain parts or types of parts. Many of these furnaces cannot be used for any other articles without first being altered, or, as often happens, entirely rebuilt. Others, particularly those designed for parts with light sections, are more flexible and can be used for a variety of items.

The above general statements are equally as applicable to the manufacture of small spring washers as to, say, ring gears. Extreme care must be exercised in the selection of suitable steels for spring washers, and the heat treatment must be such as will insure adequate hardness and strength with maximum ductility, toughness and high resistance to fatigue. They are usually made from 0.55 to 0.65% carbon steel. The material we use for the type of washer illustrated is the result of extended experimentation by our metallurgists and that of leading steel producers, resulting in a wire rod of good surface,

and of finer grain than is found in steel ordinarily furnished to this analysis. All steps in production in our own plant from hot-rolled rod to wire of keystone cross-section are under careful control; especial attention is given to the drafting program and intermediate anneals.

Spring washers may be very small both in section and weight, and yet great dependence is placed on their proper functioning. Helical spring washers, such as shown on page 153, may vary in section from 1/32 by 1/32 in. to



One of the Rotary Retorts, 12 Ft. Long, Heated With Propane, Capable of Hardening 650 Lb. per Hr. of 0.55 to 0.65% Carbon Steel Spring Washers. Time and temperature are easily adjustable to the nature of the steel or the cross-section of the part in production

½ by ⅜ in. and in weight from six pieces to a pound to 32,000 per lb. Something like 1500 sizes, cross-sections and designs are listed in the catalog. It will be evident that if the manufacturer wishes to safeguard his production, and turn out a quality product with a minimum number of rejections, it will be necessary to do as other specialty manufacturers do — develop special hardening equipment and definite heat treatment programs to fit the various designs and their intended uses. For this purpose Philadelphia Steel & Wire Corp. collaborated with American Gas Furnace Co. in the design of the furnace shown in the halftone. Its average capacity is 650 lb. per hr.

The furnace is a retort type, closely muffled so there is no chance for circulation of air in contact with hot steel. This prevents decarburization (which would not only tend to soft surfaces, but also reduce the fatigue limit) and keeps scale at a minimum. The over-all size is 12 ft. long by 3½ ft. diameter. The retort is cast nichrome, 112 in. long and 14 in. inside diameter. There are twelve burners for propane gas on each side of the furnace, their locations being such that proper heat input can be governed throughout the length of the retort. An added feature is that of controlling the burners at the intake and discharge ends separately, making it possible to bring the work up to heat in the minimum period of time to suit conditions and maintaining it through the proper soaking period before quenching.

Washers are hopper-fed to the retort, and the feeding mechanism is constructed to control the volume of work entering the furnace. As it revolves it carries the spring washers gradually through the proper heat cycle to the discharge end. They then drop through an enclosed chute into a submerged, rotating quench drum without coming into contact with the air. Washers are automatically carried from the quench tank to the cleaning equipment, where oil is removed.

Drawing is performed in Leeds & Northrup, uni-directional, dense load, homo furnaces, 1,000 lb. in a charge. Temperature and time are adjusted to the required hardness, Rockwell

C-48 to C-53, dependent upon the section. Results obtained have proved the reliability of this equipment for drawing spring washers to narrow hardness limits.

With the above type of equipment the quality of the product, independent of size or section, has been so uniform that our firm has standardized on it for all spring washers and has several such units in operation. The flexibility of these units is demonstrated when steels of other analyses than straight carbon are made and treated. A large quantity of alloy washers — principally silico-manganese, chrome-molybdenum, and carbon-molybdenum — are made and of course the temperatures and time cycles are varied to suit the steel in production. All steps in manufacture from the drawing of the keystone section from the hot-rolled bar to the final hardness check on the heat treated spring washer are under direct metallurgical supervision, and all furnaces have automatic heat controls.

This extreme care and special equipment is necessary to meet present-day assembly and service requirements. In the earlier days of the automobile assembly line, all nuts or bolts were tightened by hand. Spring washer sections were designed to meet these conditions. Now, under present high speed assembly, the nuts and bolts are tightened by high speed, high cycle socket wrenches, but only in a few instances has the section of the spring washer been increased to withstand the heavy thrust which this power wrenching imparts. This means only one thing, that the quality of the part must have been vastly improved. Taking into consideration the changed methods of application, greater speeds of modern cars and higher frequencies of vibration, it might be advisable for automotive engineers to adopt washers of heavy section exclusively, and eliminate the light ones.

While some laymen think of a spring washer as a gadget to prevent a nut from backing off the bolt thread, its real value lies in its ability to serve as a compensating member. It must exert adequate tension to keep the assembly tight after frictional wear has abraded metal from the bearing surfaces. If it does not possess sufficient "backbone" to do this, its most important function is sacrificed. Hence its principal requirements are strength to keep the assembly tight, endurance to resist vibrational stresses, hardness to resist wear, and low cost to get by the canny purchasing agent. These requirements can only be met by the most modern methods of mass production.

Temper brittleness

By Kiyoshi Nagasawa

Abstracted from Honda Anniversary Volume, Science Reports, October 1936, p. 1078

ON EXAMINING many published researches on temper brittleness, especially in nickel-chromium steels, we found some differences in the experimental data and in the theories deduced therefrom. The present writer therefore studied about 200 heats of plain carbon and various alloy steels. Some characteristics were common to alloy steels containing chromium, manganese, phosphorus, silicon and nickel and these are regarded as being variously susceptible to temper brittleness. Plain carbon steels and alloy steels with tungsten, molybdenum, vanadium, cobalt, copper and sulphur do not appreciably exhibit these characteristics, and are classed as not susceptible to temper brittleness.

In this study a large number of Izod impact pieces were made from a rolled square bar and properly quenched. Duplicate samples were then tempered at 400°, 450° .... up to 650° C. for 10 hr., whereupon one sample was water quenched and the other cooled in furnace at about 1° C. per min. The typical form of temper brittleness is shown in the diagram printed on page 214. The impact value of tempered steel should naturally increase with rise of tempering temperature (curve A-B-D-F); steels susceptible to temper brittleness show, typically, curves such as A-B-C-F for the samples quenched after tempering and A-B-C-E for slowly cooled samples. The present writer designates the embrittlement D-C as the "first temper brittleness" and the embrittlement F-E as the "second temper brittleness." Values of these in terms of Izod impact strengths, as scaled from the published curves, are as follows:

Analysis of Steel	First Temper Brittleness	Second Temper Brittleness
0.35 C, 3.00 Ni, 1.36 Cr	23	55
0.35 C, 3.44 Ni, 1.05 Cr	32	52
0.31 C, 3.03 Ni, 0.95 Cr	21	46
0.27 C, 3.12 Ni, 0.51 Cr	8	9
0.35 C, 1.04 Cr	22	37
0.37 C, 1.50 Mn	22	45
0.42 C, 0.10 P	17	47
0.45 C, 1.42 Si	16	18
0.32 C, 3.50 Ni	8	10
0.34 C, 3.04 Ni, 0.95 Cr, 0.29 Mo	14	4
0.38 C, 3.00 Ni, 1.37 Cr, 1.45 W	11	8

The occurrence of temper brittleness in nickel steel has been doubted by some; however, it was confirmed in the present research. The nickel steel tested was practically free from other impurities; it is weakly susceptible.

(Continued on page 214)

Earle Clement Smith

Chief metallurgist
Republic Steel Corp.

Underwood & Underwood, Washington

An appreciation by two associates, J. M. Schlendorf and H. W. McQuaid

THE STEEL INDUSTRY has been noted for producing men of strong individuality. The very nature of the work involved in producing and marketing steel, in which the individual plays such an important part, would tend to produce outstanding, forceful men. And it is typical of the steel industry that leaders are primarily chosen for their ability to get things done under the most difficult conditions. This has developed, particularly in the steel maker, a tendency to lay great stress upon the practicability and forcefulness of a leader rather than upon his theoretical knowledge of the tremendously involved phases of steel making.

Occasionally there develops a combination type in which outstanding practicability based on wide experience is joined with a theoretical knowledge of the highest order. Probably the most noteworthy example of this in the steel business today is found in Earle C. Smith, chief metallurgist of the Republic Steel Corp. His most outstanding characteristic is his ability to retain the common touch, so that he is known to thousands of workers in steel as "Earl" and it is doubtful if one per cent of those who know him would recognize who was meant if he were spoken of as anyone but just "Earl Smith." He is the type to whom the appellation of the title "Mister" somehow seems incongruous; christened Earle Clement, even the final *e* now seems a little out of place!

From his early boyhood, Earle was in close contact with men who worked hard for a living, his boyhood being spent near New Brighton, Pa., where he early became familiar with the mining of coal and the characteristics of the coal miners.

He graduated from Ohio State University in 1913 and up to the time of entering the employ of the Illinois Steel Co. on the openhearth floor, at Gary, he had spent time as an instructor at Ohio State and as a surveyor in Wyoming. During the War he was in charge of government inspection at the Central Steel plant in Massillon, Ohio, reporting to the U. S. Army Ordnance office at Pittsburgh. After the War his ability was quickly recognized and he was made chief inspector of the Central Steel Co. in 1919, plant metallurgist in 1920, chief metallurgist in 1922 and assistant general superintendent of the Central Alloy Steel Corp. in 1926. When this organization became part of Republic Steel Corp. in 1930, he was made assistant district manager and two years later was made chief metallurgist for the whole corporation.

This experience, which required closest possible attention to mill operations, gave him an opportunity to apply his tremendous energy to acquiring the broadest possible knowledge of every detail in the making of carbon and alloy steels. It is interesting to note that while his primary interest during these years was actual steel making, he found sufficient time to devote himself to the theoretical side of that process and to become one of the best informed theoretical metallurgists in the country today. Only a few know the hours of time and the great effort which he put, for an instance, into a petrographic study of openhearth slags, and their coordination with the operation of an openhearth furnace.

Earle Smith's ability to acquire one of the best theoretically trained minds in the steel industry is due primarily to the fact that with him this phase of steel making and application is not a task but a delightful hobby. A visitor in his home is always interested in his remarkable library and his equipment for making petrographic and micrographic studies.

It must not be inferred from the above that Earle Smith is one-sided in training. In fact, one of the characteristics which amaze those who come in contact with him is his extensive knowledge of almost any subject which might be presented. We recall such divergent subjects as the history of Scotland, conditions in China, oil field development, political situations, airplanes. This knowledge comes principally from the fact that he makes an intensive study of any subject that happens to require his attention, and he has the ability to acquire a large mass of information in a short time and to retain it indefinitely.

His position as chief metallurgist of Republic Steel Corp. requires an ability to handle men and a thoroughly well-grounded theoretical knowledge of every phase of the entire steel industry, all this combined with a thoroughly practical knowledge of all the varied operations involved in the steel industry from the mining of the ore to the successful application of the finished material. The happy combination of these three requirements to a maximum degree is found, combined with the strongest possible character and resourcefulness, in Earle Smith.

The Flow of Steel

By Frank G. Norris

As I stood looking through the furnace door,
The bath called to my mind a mountain lake
Where tiny streams of water meet to make
The source from which a river soon will pour
Its burden to the sea. Then back once more
From clouds to stream to tarn without a break
The cycle is complete. Steel charges take
A corresponding route from pit to floor.

Contaminated water from the sea
Is purified before it falls again.
The old and rusty scrap, on melting, flows
In little streams that soon find company.
The bath so formed is purified and then
From useful steel to scrap the cycle goes.

By Gilbert Soler
Manager, Research Department
Timken Steel & Tube Division,
The Timken Roller Bearing Co.
Canton, Ohio

New carbometer control speeds production and improves quality

AS METALLURGY and the knowledge of steel and its properties expand, the necessity of holding analyses within closer and closer limits becomes increasingly important. This is particularly necessary in the production of high grade alloy steels. Rigid chemical and metallurgical control is required, yet at the same time laboratory procedure must be continually improved so as to aid rather than interfere with orderly, economical production. Supplementing the chemical laboratory by giving the furnace operator a carbon check within one point (0.01%) in two minutes, the carbometer makes possible closer control in melting and thereby aids in the production of quality steel.

This instrument, only recently introduced in American steel practice, determines the percentage of carbon in a heat, using a specially designed test bar cast on the furnace floor, by measuring the magnetic induction developed in the specimen. Both openhearth and electric furnace steels are now being made at the Timken plant under carbometer control, all results being checked, of course, by the chemical laboratory.

Although this new instrument represents an important advance in control technique, it requires considerable preliminary work to utilize its advantages. Various alloying elements influence the readings, so before they can be used as a reliable means of control, a series of charts or tables must be developed relating chemical compositions with the carbometer readings. Likewise it is essential that the men in charge be trained in the preparation and testing of samples.

Advantages—The advantage gained lies in the fact that an accurate and rapid test can be made by the furnace operator at any time during the working and refining of a heat. Checks in the chemical laboratory take a greater time, and as the actual conditions in the bath are usually changing rapidly, more accurate melting control is obviously obtained with more rapid estimation of chemical analysis. The amount and time of ore additions are more readily determined as well as the time of alloying and deoxidizing additions. Over-deoxidation of the bath is avoided, and considerable time is saved in making the heat.

It is well known that the slag and steel conditions as well as the temperature are changing rapidly under an oxidizing slag. The slag is changing in composition, viscosity and state of maturity, and this affects the rate of reaction with the metal bath as well as the transfer of oxygen from the furnace gases to the slag. A skilled melter judges the condition of his slag to a fair degree with simple qualitative tests, but is dependent on the chemical analysis of the steel, especially in regard to carbon, in order to judge the reactions between slag and steel. Fracture tests are taken in an effort to determine the carbon content roughly, so that no time will be lost in adjusting the operations, but the value of such tests is always affected by the individual skill of the man making them. As already said, the carbometer provides a scientific means of checking the carbon content of the bath accurately and quickly.

While the carbon content is extremely important in the removal of manganese and

Whenever It Is Desired to Know the Carbon Content of a Heat, a Spoon Sample Is Taken, Skimmed, Deoxidized With Standard Length of Aluminum Wire, and a Test Bar Cast in a Mold, Warm and Dry

phosphorus, this action is also affected by the temperature of the bath and the amount of iron oxide which is in the slag, together with the character and composition of the latter. Likewise, the carbon content in the metal limits the oxidizing action that occurs on the bath; it also makes possible the boil, which provides a means of stirring the bath, equalizing its temperature and increasing the contact between steel and slag which is required for the reactions to proceed at a rapid rate. This rate of reaction can be readily determined by carbometer tests on the furnace floor, thus enabling the melter to operate his furnace most efficiently.

Preparation of Samples—Test samples are taken from the furnace in the usual manner. After skimming the slag from the spoon a standard amount of aluminum wire is added to deoxidize the metal, which is then carefully poured into a special mold. When the mold is filled it is tipped to spill the liquid metal in the pouring basin or head of the test sample, as excess metal would reduce the rate of cooling and influence the carbometer readings.

If the carbon content of the sample is over 0.40%, the test bar is immediately knocked out of the mold, seized by the head with a pair of tongs and quenched in a pail of cold water. If the carbon content of the sample is under 0.40%, the test bar is allowed to remain in the mold exactly one minute, then removed and quenched. Care must be taken to seize it by the head and dip it vertically into the cooling water to avoid distortion or non-uniform cooling. The cooling fluid must be clear water, not contaminated by salt, oil or soap and at a temperature of 60 to 80° F. After immersion the bar is swished around briskly in the water and not taken out until completely cooled. It is then dried with a cloth and any burred edges on the sample removed with a few strokes of a rough file, and is ready for the test. Ordinarily two samples are cast to avoid the possibility of using an occasional faulty one.

Taking Carbometer Readings—As soon as it is cool and dry, the test piece is inserted in a funnel shaped hole in the carbometer and the clockwork wound by a single turn of a crank. This clockwork drives an armature; the test piece is magnetized thereby when the operator depresses the correct button on the instrument. When the armature stops rotating, which is indicated by a series of sharp clicks, another button is depressed which closes a switch in a circuit leading to a galvanometer. The galvanometer reading is then converted to the corresponding carbon percentage by using charts, prepared in advance for the individual piece of equipment in use.

Rotation of the armature exposes the test piece to the alternate action of two magnetic fields of different intensity during each 90° of rotation, the fields being equal in strength at each 180° of rotation. The magnetic induction within the test piece increases by decreasing increments with each successive alteration in field strength until a relatively constant value is

obtained. Inasmuch as the speed and number of rotations of the armature are controlled by the clockwork, each sample is energized in the same way, and the mechanism is such that the armature always stops in the position of highest magnetic field strength. Depressing the second button allows the armature to revolve 90° to the position of lower field strength, whereby a charge of electricity is induced in the coil surrounding the test sample, proportional to the change in magnetic induction in the test piece. This charge is measured by means of a separate ballistic galvanometer, connected to the carbometer, the galvanometer being switched in while the armature completes the last 90° turn.

The carbometer is equipped with a switch by means of which it may be adjusted for two different ranges of readings, one for hardened test bars (0.35 to 1.60% carbon) and the other for unhardened test bars (0.40% carbon or less). Both carbometer and galvanometer must be placed in a room free from large temperature variations and the galvanometer protected from vibration. (In the view it is hung from four springs.) Provision is made for checking the equipment periodically, using a standard test bar to assure that the instrument is in adjustment.

Effect of Alloying Elements—As the carbometer readings taken from the galvanometer are not relative to the induction at a certain strength of the magnetic field, but to the difference between the induced current caused by two fields of different strength, alloying elements exert only a comparatively slight influence on the readings. It is, however, essential that these factors be taken into consideration to obtain the maximum benefits possible in the way of quality control.

If the Carbon Content Is Above 0.40% the Test Bar Is Quenched Immediately to Full Martensitic Microstructure. If of lower carbon it is cooled in mold exactly 1 min., then quenched; it then has the microstructure of a raw steel casting, being quenched from below the critical temperature

The instrument is used more for carbon determinations during the oreing and refining period of a heat than during the deoxidation stage. Consequently, tables must be prepared which show the influence of those alloying elements normally present in the charge after melt-down, and are therefore based on the use of a reasonably constant analysis of materials used in the charge, particularly the alloy scrap. Actual values are further influenced by the relative oxidation losses of the elements present in the charge and the residual amounts which will be present during the periods when tests are taken.

A Simple Routine in the Cabinet Leads to a Deflection of a Pointer on a Galvanometer, and This Is Related to Carbon Content in the Test Bar. Note duplicate test bar is lying on the carbometer top near operator's hand

Silicon is fairly well oxidized from the steel bath by the time the heat is melted and the first samples taken. As the residual silicon at meltdown is generally less than 0.10%, no effect of this element is noted on carbometer readings.

Phosphorus and sulphur present in the bath are too low to have an effect on the readings.

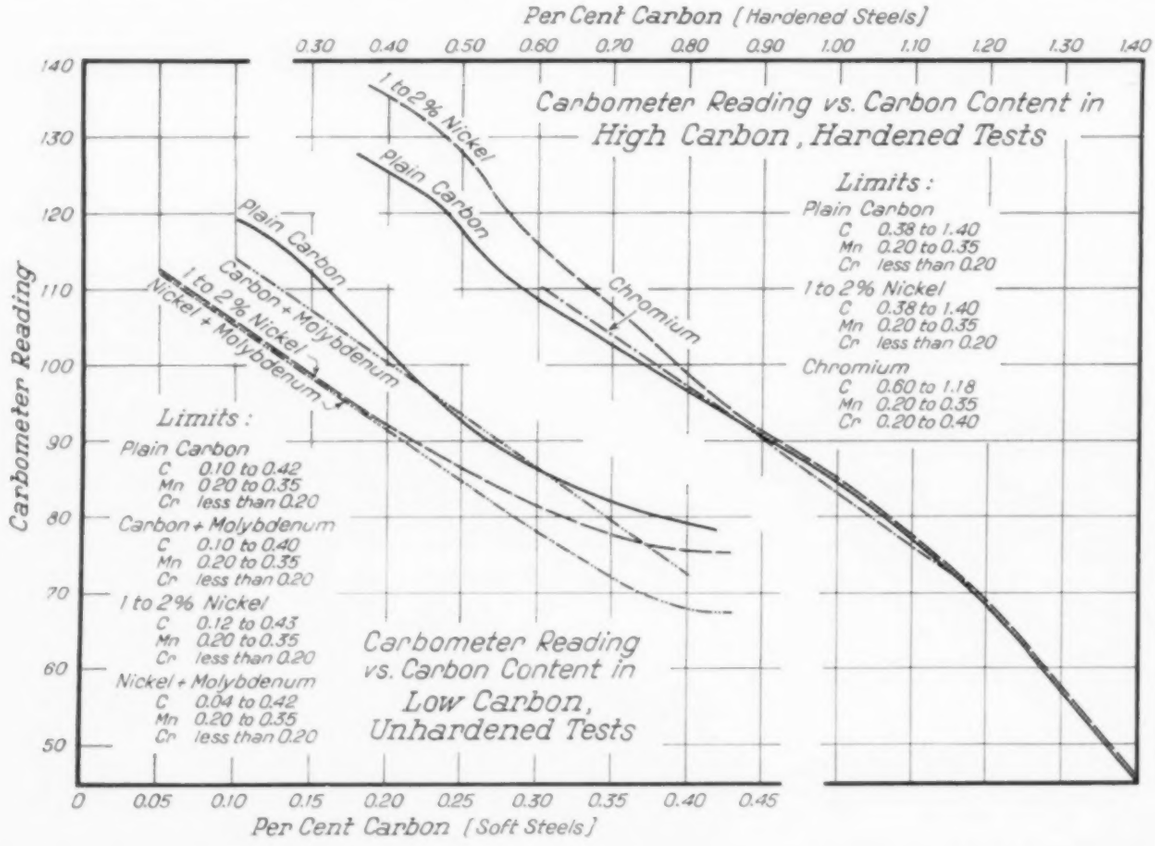
Manganese residuals usually lie between 0.20% and 0.35% and do not appreciably affect the relative readings. If it should be higher, as may be the case in some high carbon heats, the true carbon content may be 0.01% lower than the carbometer reading indicates, but this will not materially affect subsequent additions and operation. (If the reverse were true, such a condition *would* be dangerous, as the melter might proceed to work or deoxidize the heat while the carbon content was still too high.)

Nickel does not oxidize appreciably in the steel bath, so its presence must be compensated for when taking carbometer readings, but once the proper corrections are established there will be little variation, as the nickel content will remain constant. Its effect on the galvanometer readings is greater as the carbon content of the bath is decreased. Since nickel is ordinarily present in considerable amounts, its presence must be known to secure accuracy in this test.

Molybdenum is not oxidized appreciably in the bath, so that its presence must also be compensated for by making suitable corrections on the chart for amounts exceeding 0.10%.

Chromium oxidizes to a fair degree in the bath, so that only when the residual amount exceeds 0.20% is it necessary to apply a correction factor. Ordinarily in openhearth practice the chromium residual is less than 0.20%. However, in electric furnace practice, where high chromium scrap is used and the bath is practically dead-melted, chromium is a factor.

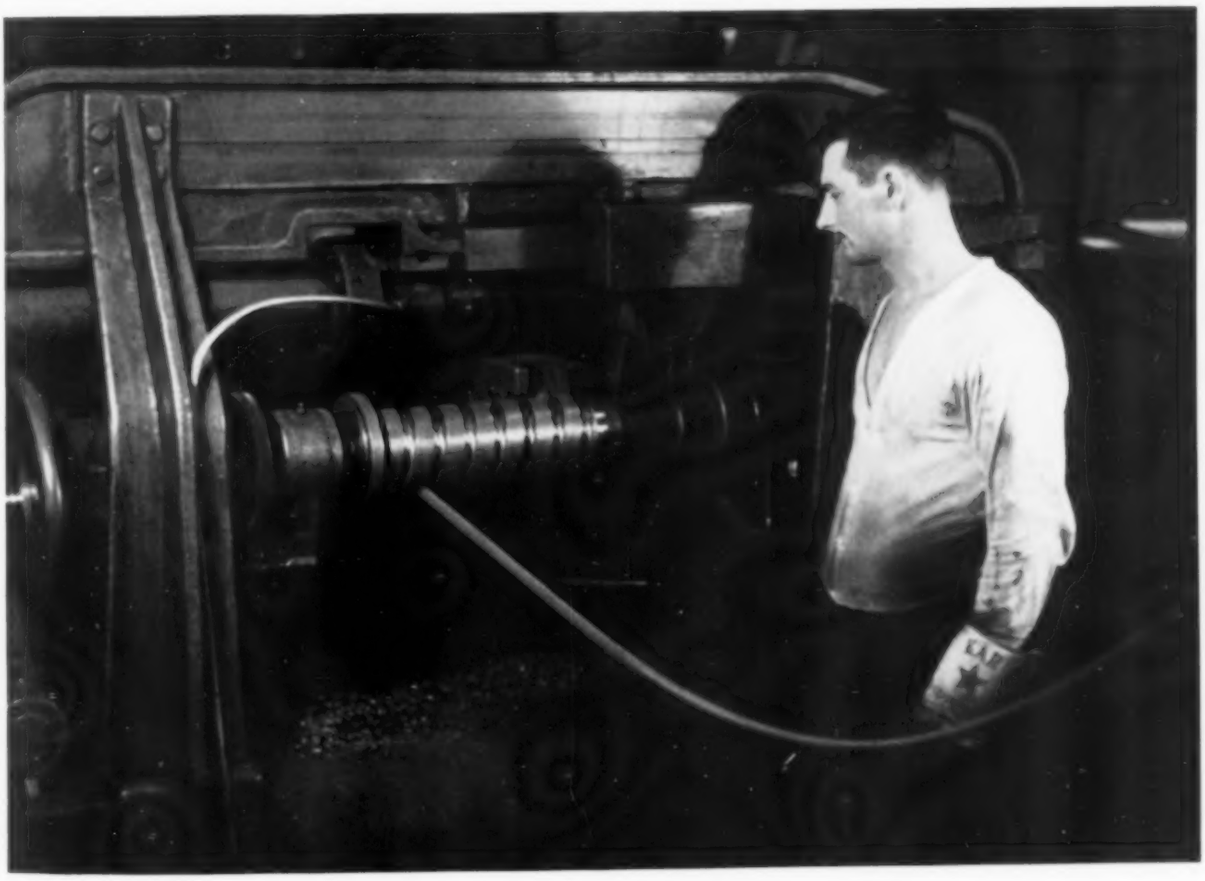
The accompanying charts developed by the Timken Steel & Tube Division's research department illustrate the effect of nickel, moiybdenum and chromium on the readings of the carbometer in use at this plant as compared to plain carbon steel with its usual residual elements. All test specimens were carefully analyzed for carbon and other alloying elements in the chemical laboratory.


Per Cent Carbon [Hardened Steels]
0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40
Carbometer Reading vs. Carbon Content in High Carbon, Hardened Tests
1 to 2% Nickel
Plain Carbon
Chromium
Limits :
Plain Carbon
C 0.38 to 1.40
Mn 0.20 to 0.35
Cr less than 0.20
1 to 2% Nickel
C 0.38 to 1.40
Mn 0.20 to 0.35
Cr less than 0.20
Chromium
C 0.60 to 1.18
Mn 0.20 to 0.35
Cr 0.20 to 0.40
Carbometer Reading
140 130 120 110 100 90 80 70 60 50
Plain Carbon
Carbon + Molybdenum
1 to 2% Nickel
Nickel + Molybdenum
Limits :
Plain Carbon
C 0.10 to 0.42
Mn 0.20 to 0.35
Cr less than 0.20
Carbon + Molybdenum
C 0.10 to 0.40
Mn 0.20 to 0.35
Cr less than 0.20
1 to 2% Nickel
C 0.12 to 0.43
Mn 0.20 to 0.35
Cr less than 0.20
Nickel + Molybdenum
C 0.04 to 0.42
Mn 0.20 to 0.35
Cr less than 0.20
Carbometer Reading vs. Carbon Content in Low Carbon, Unhardened Tests
0 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45
Per Cent Carbon [Soft Steels]

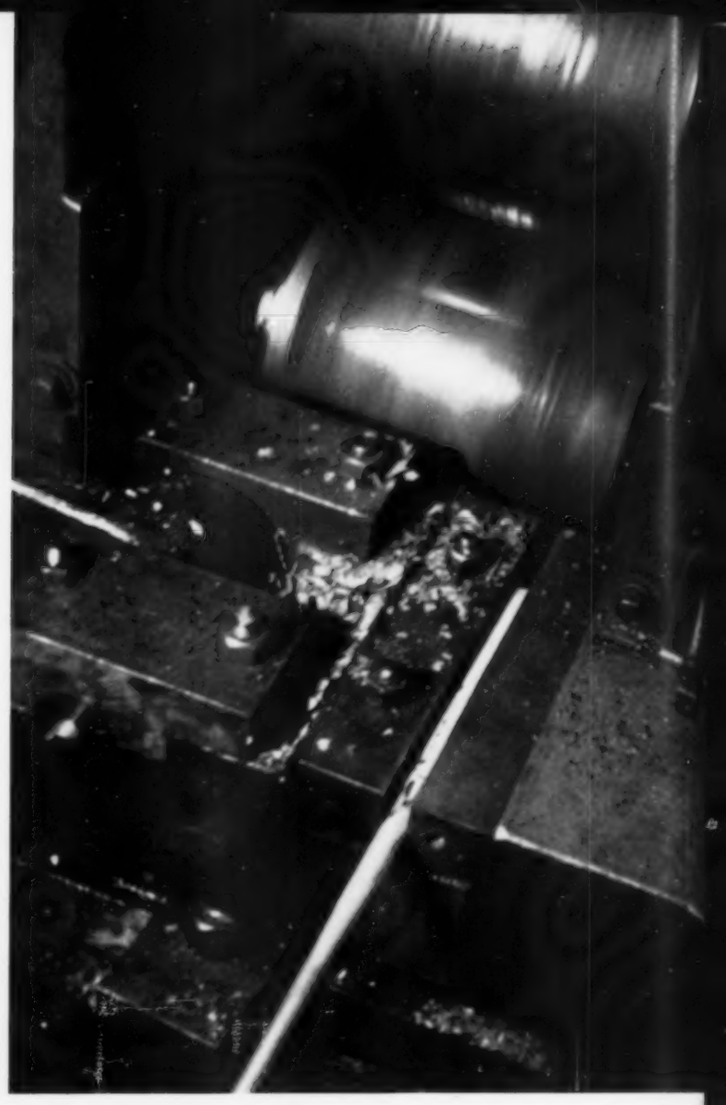
Openhearth Practice—In making an openhearth heat in the Timken plant, a sample is sent to the chemical laboratory and a carbometer reading taken when the heat is melted and the lime is up. From *(Cont. on page 200)*

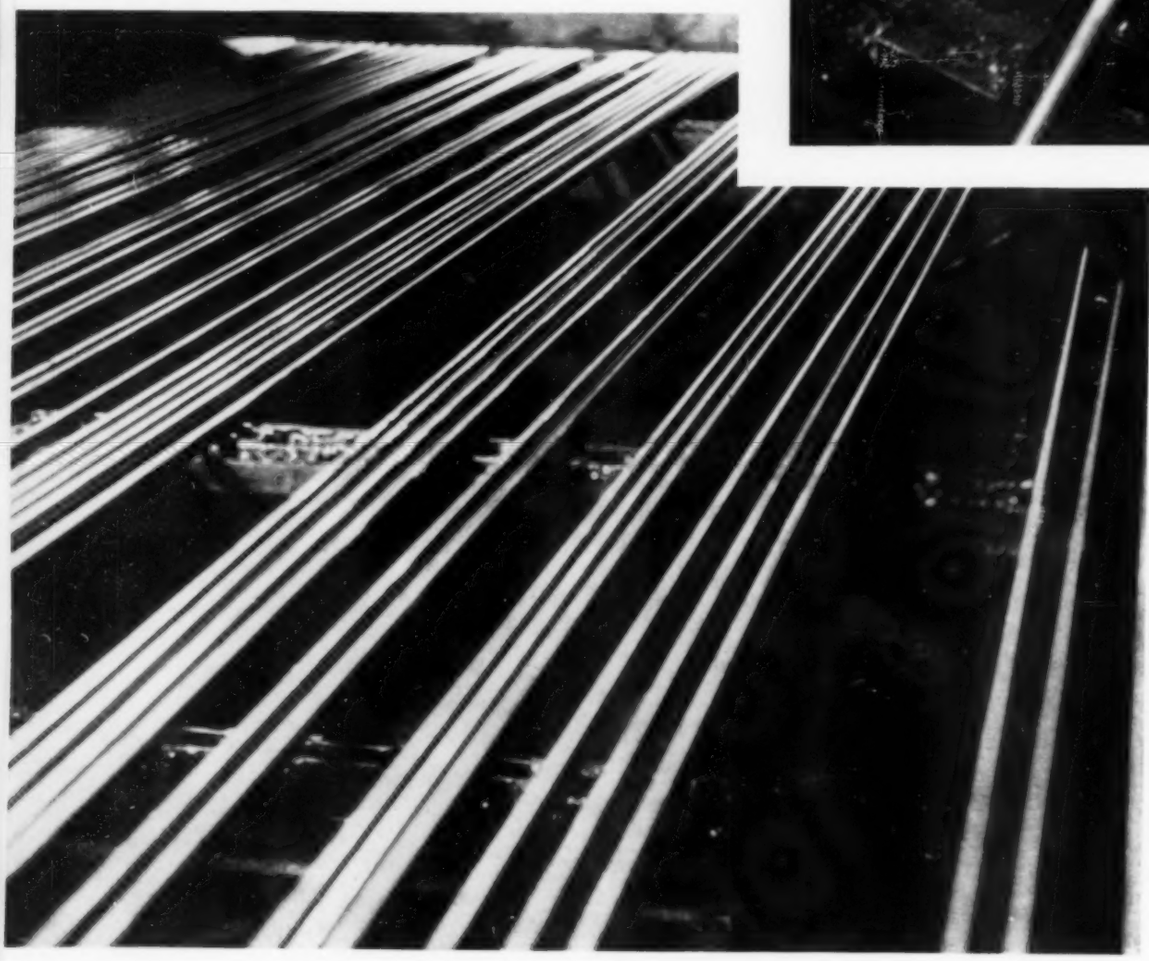
Helical springs for automobile front ends

Photographed by Van Fisher at Buick Motor Co., Flint, Mich.



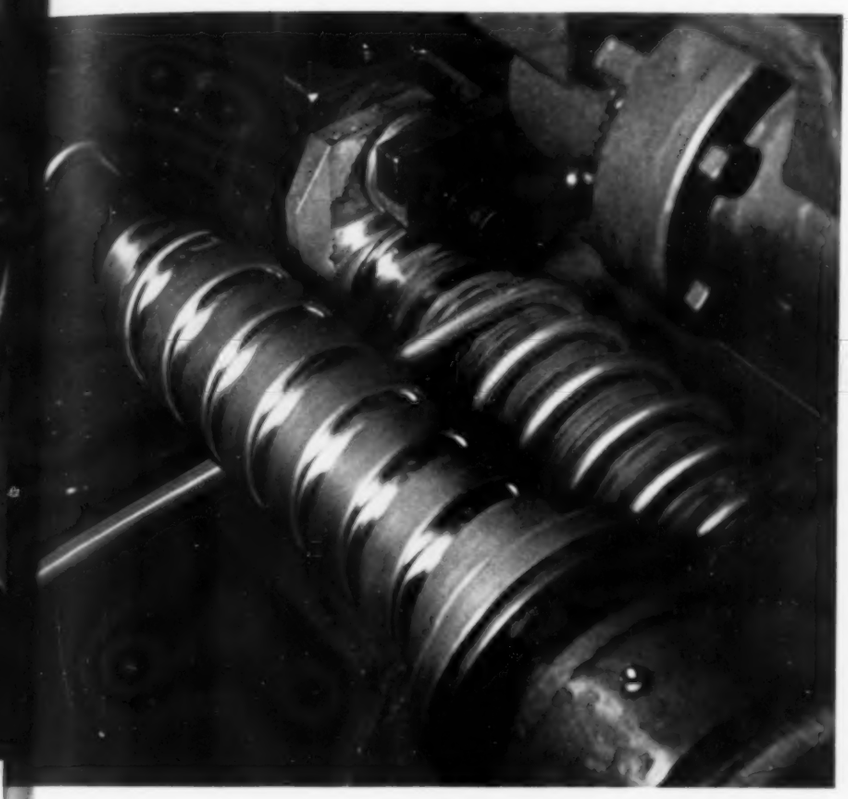
IT IS SURPRISING how much rod is required for a single coil spring — about ten feet of it, beautiful steel, straight as an arrow, surface ground exactly round to remove mill scale, soft skin and other superficial defects. First operation is to taper the ends. Preliminary heating is in the forge furnace shown below. It has a long, narrow slot in its front wall, and a bank of rods is carried slowly sidewise by chain belts so only the end placed in the furnace is heated.



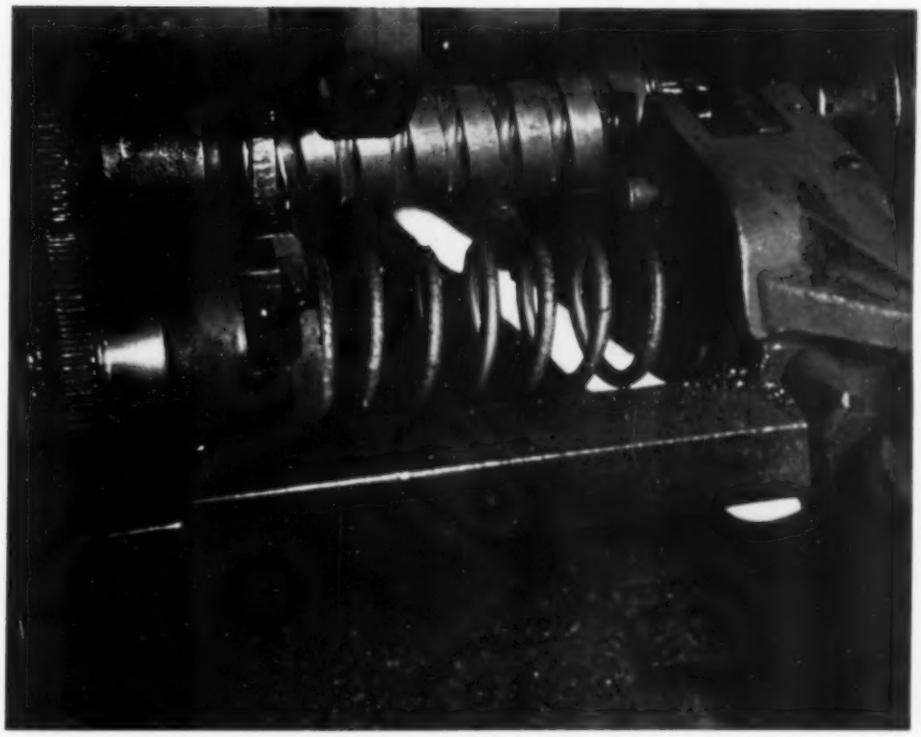


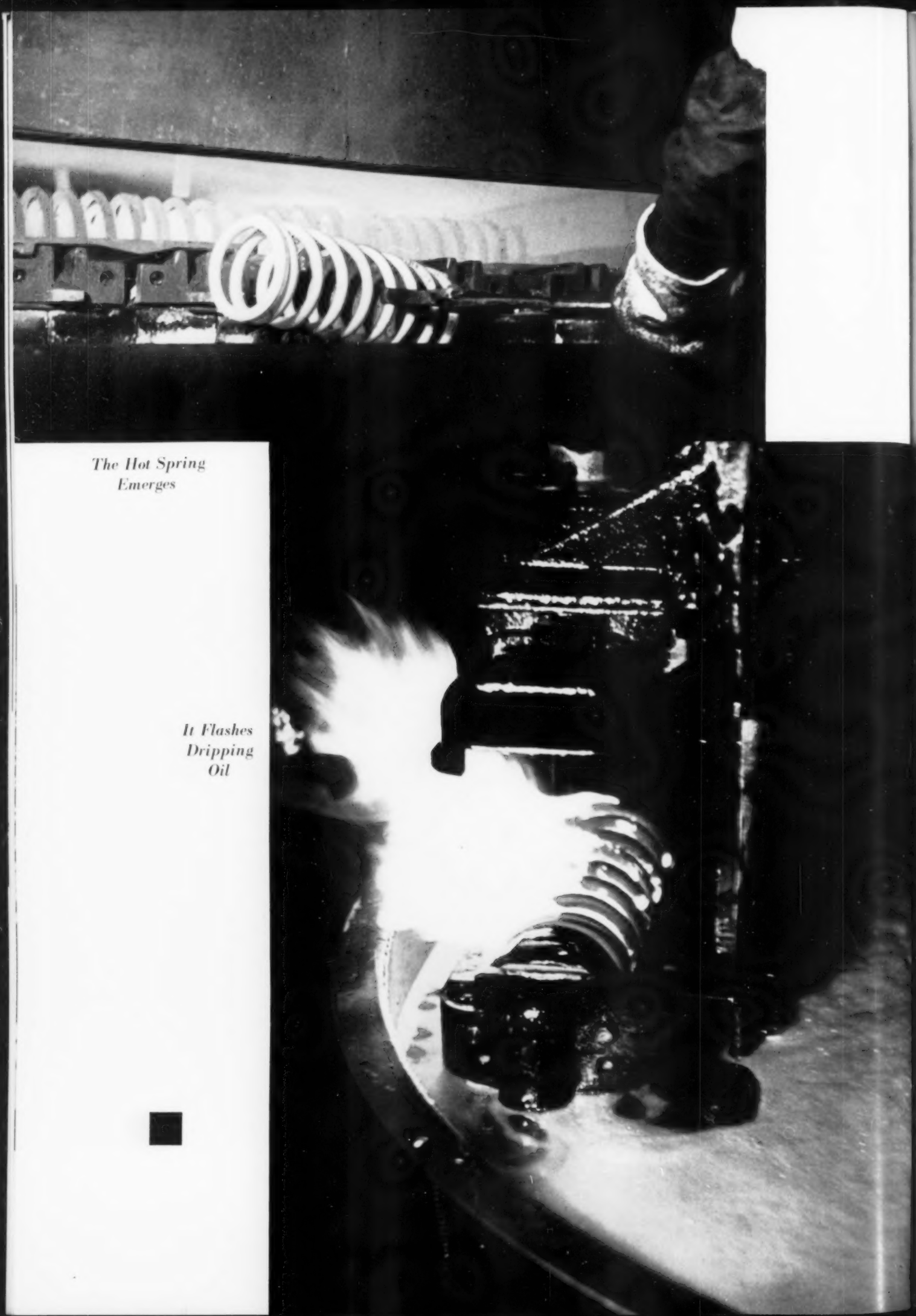
One by one a workma slips their glowing en between two forging roll These forging rolls are ca shaped, geared togethe and on each turn wi pinch a bar thrust betwe them and push it bac gradually squeezing th end down to a chisel poi Sidewise the bar is kept t dimension by dropping now and then between th reciprocating anvil jaw where it is now to be see

Both ends pointed, the entire bar is brought to a bright red heat. Atmosphere is controlled in this furnace to avoid decarburization, for soft skin due to low carbon steel on the surface is known to cause early failure in severe service. One end is caught by a grip at the right end of a smooth, round mandrel, and as it turns, winding the hot rod about itself, the correct spacing is maintained by the spiral groove in front, turning at the same speed as the mandrel. The very end of the rod enters under the small roller shown at the left end and so is wiped down clean.



The mandrel is pulled to the left, freeing the spring, which can then be lifted out and set on end to cool. The view below is taken at the rear of the machine. Note the paper-like scale which forms while the hot rod is exposed to the air in the minute or two required to coil it into a spring.





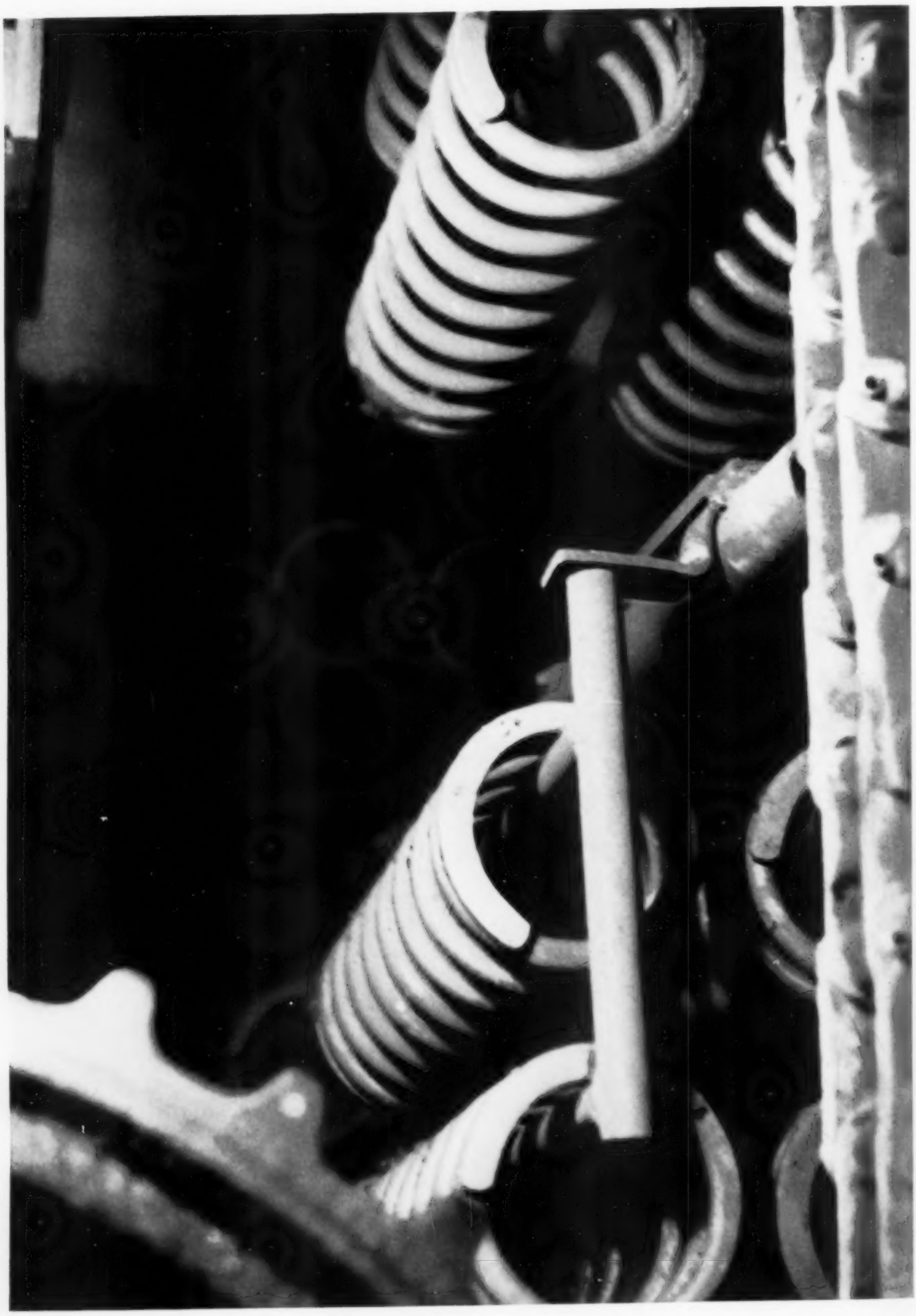
The Hot Spring
Emerges

It Flashes
Dripping
Oil

SINCE automobile springs must stand up under innumerable shocks — even closures until they bump — they must have an endurance limit in alternate bending above 85,000 psi., and this means an ultimate tensile strength of about 200,000 psi. (and a definitely high yield point to prevent a gradual sag). These properties demand quenched high carbon steel, fine grained, alloyed with vanadium, molybdenum, or silicon and manganese. Heating prior to coiling may coarsen the grain, and coiling itself may set up uneven internal strains. Consequently, the best springs must be cooled slowly and evenly after forming and then reheated slightly above the critical range to refine the grain. Quenching is done in a fixture which not only holds the spring to shape but sprays it with oil jets under pressure, even as the fixture and its contents are totally immersed.

Souse! Everything Submerged

Out Comes the Hardened Spring



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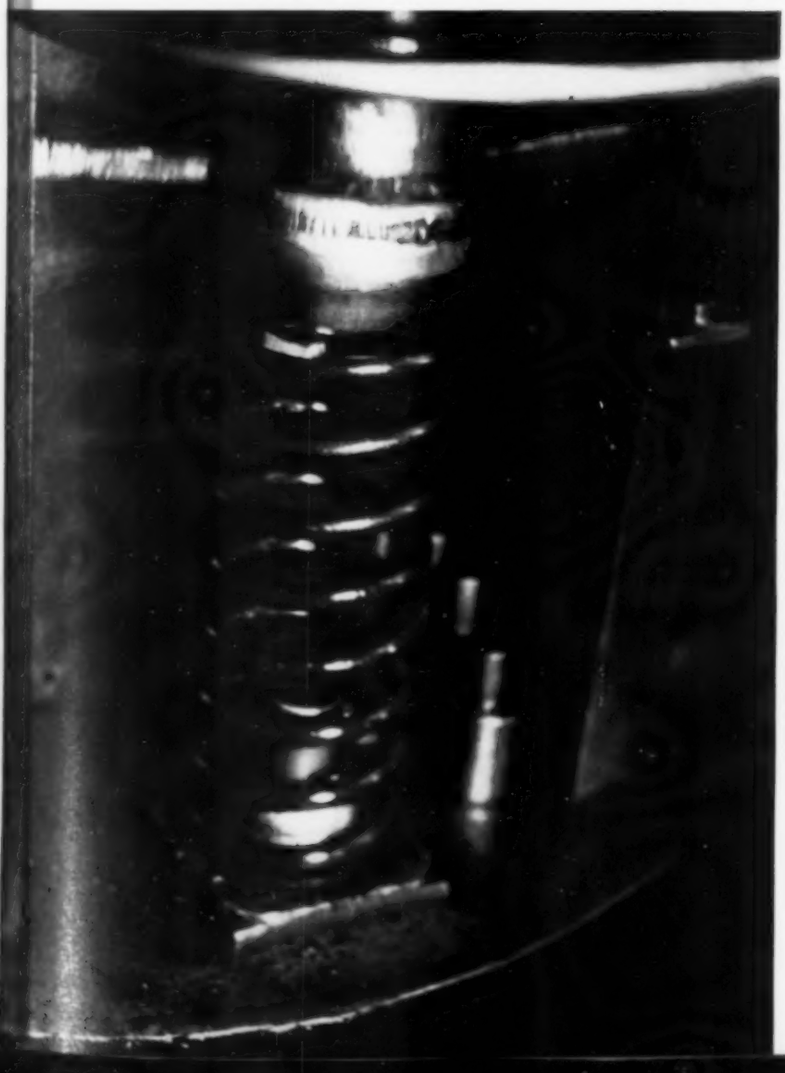
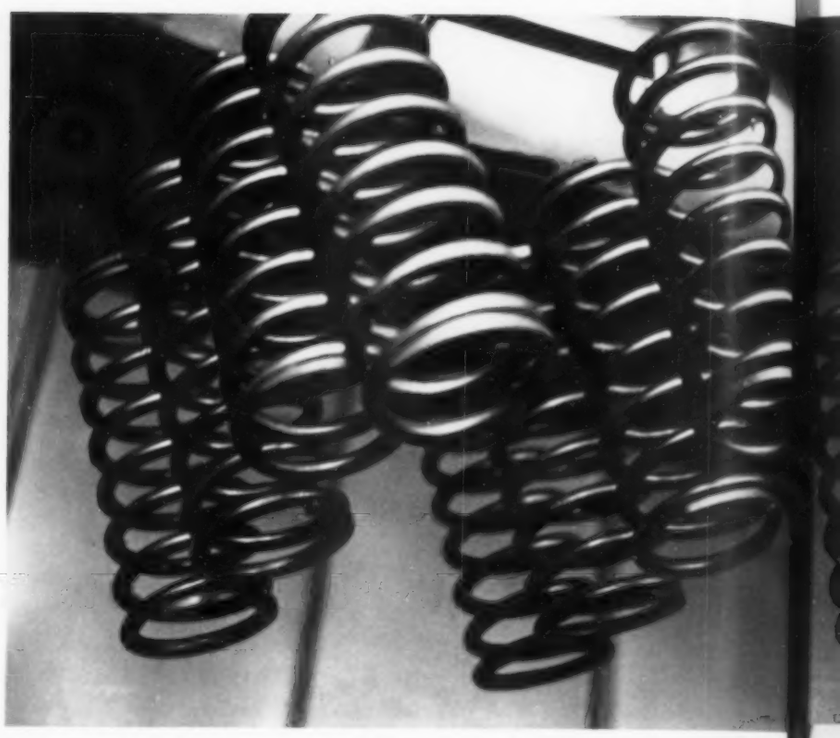
uenched springs are then empered. At the Buick plant Flint this is done on a ain conveyor, traveling up d then down in a tall shaft- e furnace. Here they are, ssing the unloading sta- on, ready to be taken from e supports, fully tempered, t before the conveyor ain goes around the bot- m sprocket for reloading.

After heat treatment the ends are ground square and the spring is settled to its correct dimensions — that is, to a stable free height — by compressing it solid a few times. As shown below, this is done on a small quick-action press.



Next comes careful cleaning. The surface is wire brushed or gently blasted free of scale. Visual inspection searches out minor flaws which would encourage corrosion pits or fatigue cracks. A diamond impression measures its hardness. It is gaged for outer and inner diameter and pitch of helix. Then a final inspector checks its loading characteristics by weighing the load required to compress it to definite heights. As can be seen, the limits are very close.



Hooked on a conveyor chain, the cleaned and perfect springs dip into a lacquer bath, for a flexible, tough, waterproof coating to protect them from the elements throughout their life.

Up and out of this liquid, and through
oven for drying, they are carried overhe
to the assembly line, there to enter the co
pleted car as the life of "knee action."
the words of its p
ponents, "No inno
tion," (it is no long
an innovation) "no
novation in the ent
history of the au
motive industry h
ever been so th
oughly tested a
proved as has 'kn
action' constructio

METAL PROGRESS has printed much about automotive springs. In this very issue you may read Mr. Boegehold's remarks on page 151. If you are interested in fabrication problems, you would enjoy the article on manufacture and testing of hot formed mechanical springs by Messrs. Peycke and Clyne in the issue of May 1936 (page 44). As to the problem of an easy ride, the Editor appraised the theory of independent wheel springing and the relation between springs and shock absorbers in March 1935 and February 1934.

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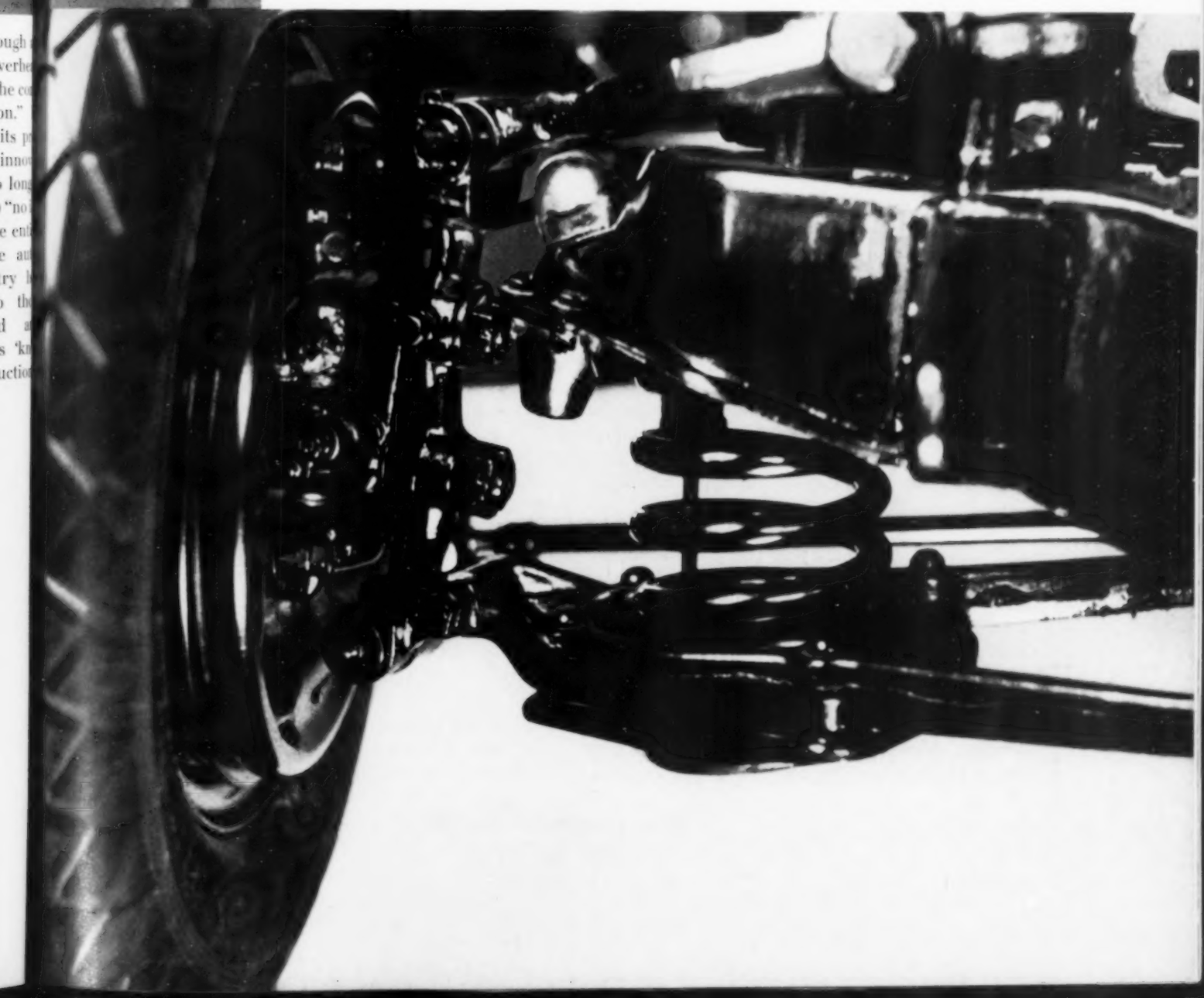


Correspondence and foreign letters

Control of Throwing Power in Electrolytic Baths

Special letter to METAL PROGRESS
by Albert M. Portevin
Bessemer Gold Medallist, 1935

PARIS, *France* — The protective value of an electrolytic coating against corrosion depends primarily on its thickness. The experiments of Blum, Strausser and Brenner of the U. S. Bureau of Standards have shown, for instance, that the protective value of nickel deposits on steel depends almost entirely on this factor. For good protection thickness must be at least 0.0005 in. under average conditions and 0.001 in. under unfavorable conditions.

However, on parts of various shapes the thickness of the deposit is far from being uniform, varying considerably on projections and in hollows. The minimum thickness found in cavities is important. This depends on throwing power of the solution, which, in turn, depends on numerous factors associated with the operation of the electrolytic tank.

Therefore the problem is to find a direct means to control this throwing power.

In experiments undertaken with Michel Cymboliste we used a dihedral test piece with faces at right angles on which the distribution of the metallic deposit was determined by weight. This complicated test piece requires precision manufacture, is expensive, can be used only for laboratory tests and not in the workshop, and finally the results are not very sensitive to changes in conditions. Because of its sharp angles it does not permit the study of high current density and long periods of electrolysis, since tree-like or branching formations break off and deposits burst. Results are also influenced by the location of the test piece with reference to the anode.

To avoid these disadvantages, we had recourse to a test piece shown in the halftone, composed of coaxial helices 0.20 and 0.75 in. diameter, made of 24-gage wire, each helix having a surface of exactly 10 sq.cm. (1.55 sq.in.). Two non-conducting screens made of ebonite protect the ends of the coils and give an essentially uniform deposit along the entire length. This deposit encircles the wire and consequently does not come off, even when the deposits are brittle and not very adhesive; thus baths in unusual and abnormal conditions of use may be studied. This test piece, which can be easily made from any ductile metal, may be placed at any point in a tank of any dimensions, and will give good results on condition that the vertical axis is parallel to the general direction of the evolution of gas and the consequent convection currents. The increase in weight p and P of the interior and exterior helices respectively is measured, and the throwing power π is computed by the formula $\pi = 100\ p : P$.

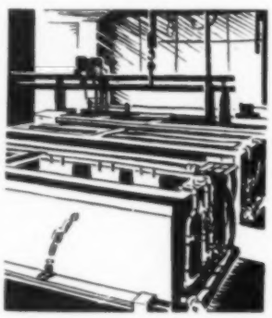
With such a device it is easy to determine the influence on the throwing power of operating variables and of certain characteristics of the bath such as temperature, concentration, acidity, viscosity, cathodic polarization, conductivity, output and presence of organic or mineral substances. These studies were made by M. Cymboliste and myself, and from the results the following general conclusion may be drawn:

All of those factors that shorten the time necessary to obtain a metal deposit of a de-

Double Helical Test Piece for Control of Throwing Power in Electrolytic Baths. This test piece is shown "in action," immersed in a bath in which an artificial evolution of gas has been produced to show the free circulation of liquid around the coiled cathode

termined thickness — such as increased temperature, high current density or high concentration of the bath — decrease the throwing power. These are precisely the factors that characterize modern plating practice. Following the general tendency toward speed-up that characterizes all modern activities, the rate of deposition has been increased without taking into account the fact that such haste increases the variation in thickness of the electrolytic coating by lessening throwing power of the solution. Such rapid work therefore leads to the danger of insufficient thickness in hollows or distant areas, although the thickness is ample at other places. For this reason much time is now spent in determining the corrosion protection given by modern electroplating operations, while formerly with more deliberate operations, properly carried out at a low current density, better protection was given to the complete part.

The main conclusion is that heavy thicknesses obtained rapidly do not necessarily mean that the stability of the whole part is improved. Here again is an example of heedless increase in speed regardless of quality. ALBERT PORTEVIN



Diagnosing Failures by Appearance of Fracture

Special letter to METAL PROGRESS
by Dr. Hans Diergarten
Metallurgist, SKF Ball Bearing Co.

SCHWEINFURT, *Germany* — A new viewpoint on the design of structural members and machine parts refers particularly to the endurance of materials and to fractures caused by stress concentrations due to faulty design or workmanship. Work in the materials testing laboratory of the Darmstadt Technical College under the direction of Dr. A. Thum has been particularly successful in developing these new principles of design. Dr. Thum, both through his own work and that of his students and associates, has contributed greatly to the development of this field in Germany.

The work begins, for instance, with the correct design of rivets in simple joints and progresses on to an understanding of the stresses arising in complicated parts such as crankshafts. A brief account of the work on crankshafts was given in my letter published in last November's issue, and it should be of interest to report some other aspects of this large investigation.

We will refer mainly to F. Meyercordt's interpretation of the relationship of stresses to the appearance of the fracture. This was reported to the convention of the *Verein Deutscher Ingenieure*, held in Darmstadt in the summer of 1936. The complete text is given in a special volume commemorating the event; some 23 engravings are used to illustrate principal types of fractures occurring in service.

Fractures in machine parts can, upon visual examination, be attributed to one of the following principal causes:

1. Poor design of the part.
2. Notches or re-entrant angles too sharp; tool marks are of this nature.
3. Wear, causing a change from vibrating to impact stresses.
4. Deformation of the structure by poor assembly (erection stresses).
5. Local overheating.

Extensive research by many men in several countries has been put into the mechanism of failure, either under steady load or under vibrating load, and the principal facts are fairly well known to progressive engineers — in fact, they have been using the results

in their designs, either to lessen the danger of premature failure or to lighten the structure within the limits of safety. Thus, it is well known that when tensile stresses surpass the elastic limit of the metal, plastic flow occurs by sliding along so-called slip planes in crystals, where crystallographic planes of low shearing resistance are disposed at an angle of about 45° to the direction of the principal stress. Should this slip surpass a certain amount, depending on the material and the condition of the stress, cohesion is destroyed and fracture results. On the other hand, alternating stress, either in bending or in torsion, causes a backward and forward movement on the slip planes. Should the stresses be larger than the "endurance limit," a gradual embrittlement or breaking up of the material along the moving surfaces occurs and cohesion is destroyed.

These different reactions naturally result in fractures of different types. Thus, inversely, it is possible, with an accurate knowledge of these

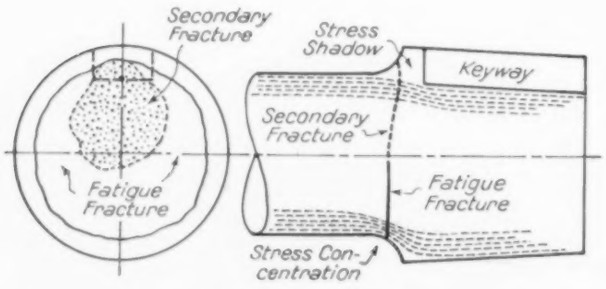


Diagram Showing How Fatigue Fracture in Axle Starts at Stress Concentration, and Secondary Fracture Occurs at "Stress Shadow." After Meyercordt

phenomena, to conclude from the appearance of the fracture what type of stress caused it. Still other factors enter into torsion impact of hardened steel, and therefore the behavior of the soft structural steels in contrast to the hardened alloy steels must be taken into consideration in order to avoid error in appraisal.

In examining fatigue fractures occurring in service, one should first of all examine them for characteristic markings indicating whether failure is due to normal (bending) or to torsional stress. It is then possible to determine the load at eventual failure by measuring and studying the portion last to give way — an area which may be termed the secondary fracture in residual sound metal.

The following observations might be made concerning the progress of fatigue fracture through irregular machine parts: Fatigue fracture does not follow the shortest path through the part but rather favors a direction toward the thickest section so that a dish-shaped fracture is eventually produced. The less intense is the overstressing and therefore the slower the fracture, the more the crack is inclined to follow the thicker part of the shaft; that is, its path will be the more extended. With increased overstressing, fracture progresses more rapidly and the iridescent, dish-shaped aspect is correspondingly less apparent; with even greater overstressing the fracture runs squarely through the cross-section.

However, not only the course of the fatigue fracture is influenced by the field of stress, but also the location of the secondary fracture. This can be noted in the broken axle shown diagrammatically in the sketch. Because of the shoulder and the keyway in the upset end, the lines of force are squeezed together from beyond the fillet to where the fracture begins below. The section near the shoulder at the keyway lies in a range of lower stress which is designated "stress shadow" *(Spannungsschatten)* and locates the secondary fracture.

Irregularities in the condition of the surface are of special influence as well as imperfections in the interior of machine parts. Just as fine cracks on the surface give rise to partial fractures, which later join to form one total fracture, graphite flakes occurring in the interior of cast iron parts subjected to heavy local overstressing at their edges, will also serve as starting points for early fatigue fracture. The more finely divided the graphite and the higher the notched bar fatigue strength of the groundmass, the higher will be the fatigue strength of the article made of such cast iron.

In this connection, the appearance of the fracture also gives some information concerning blackheart malleable iron. While the fatigue fracture appears white, the secondary fracture is black. The fatigue fracture proceeds practically without deformation; in the secondary fracture, on the other hand, the material is plastically deformed to such an extent that it appears dark. Experiments at the materials testing laboratory in Darmstadt proved that the black color could be attributed to tensile fracture and not to inclusions of black temper carbon. This new viewpoint therefore attributes the varying aspect of the fracture to varying amounts of plastic deformation.

Temperature changes, which always occur

to some extent, will cause stresses in the material just as do other forces, especially if the part is rigidly held and is of material with a high coefficient of expansion. These frequent temperature changes can cause small heat cracks which may eventually enlarge to form a fracture. Instances are fractures in valve seats and in piston heads for diesel motors.

HANS DIERGARTEN

Rapid Corrosion Tests ("Mylius Number")

Special letter to METAL PROGRESS
by Federico Giolitti
Consulting Metallurgist

TURIN, *Italy* — Various processes have been proposed lately for the rapid approximate determination of the resistance of aluminum alloys to chemical corrosion. Three among these (of which two have been proposed by Mylius) have been more generally adopted in Europe, and give very useful and reliable preliminary results, usually in satisfactory agreement with those of the other corrosion tests, more or less standardized, which have the great disadvantage of requiring a very long time.

The first of these methods is based on the temperature changes of a 10% solution of hydrochloric acid reacting on the alloy. The "reaction number" or "Mylius number" indicating the corrodibility of the alloy is given by the average increase per minute of the temperature of the hydrochloric acid solution between 20° C. and the maximum temperature reached by the solution during the experiment.

In order to obtain comparable results, the most scrupulous attention must be given to all details of the experiment. Besides the evident necessity of operating under constant general conditions — such as the form and dimensions of test pieces, quantity of acid solution, and so on — the greatest care must be taken as to the

Do you recognize this metal working plant?

Evidently the air-view of an unidentified metal working plant on page 72 of last month's METAL PROGRESS was a hard one to recognize, or else was located off the beaten track. At press time only four correct identifications were received. It is the Rome Division of Revere Copper & Brass, Inc., at Rome, N. Y. Framed copies of the original have been sent to L. E. Gibbs, Rome, N. Y., W. W. Sieg, Bellefonte, Pa., Carl O. Windrath, Rome, N. J., and Maurice G. Steele, Baltimore, Md.

purity of the hydrochloric acid. Its initial temperature must be exactly 20° C. The test piece, whose surface should measure approximately 2000 sq.mm. (3 sq.in.), must be carefully washed in a cold solution of sodium hydrate, strongly brushed, and finally washed in pure water. Then it is immersed for a few seconds in a dilute solution of hydrochloric acid, washed again in pure water, and carefully dried. The apparatus generally used for this test in European laboratories consists of a vertical glass test tube containing the acid solution, which is isolated thermally from its surroundings as efficiently as possible.

The second process is based on the measurement of the volume of gas developed in a certain time when the metal is dissolved in a given quantity of a 5% aqueous solution of hydrochloric acid at 20° C. Much the same precautions as mentioned above must be observed when making this test.

The third process, also proposed by Mylius, is based on the loss of weight of a test piece of the alloy, after a 24-hr. immersion in an oxidizing salt solution. The test piece, carefully cleaned and weighed, is immersed in 20 cc. of an aqueous solution containing 3% hydrogen peroxide and 1% sodium chloride. The temperature is then maintained at 20° C. for 24 hr. whereupon the test piece is carefully washed in nitric acid and then in pure water (in order to remove the alumina and other products formed on its surface), dried and weighed. The loss of weight thus determined is usually expressed in grams per square decimeter.

Evidently these rapid tests cannot be taken as a real measurement of the corrosion resisting properties of a given alloy, but (when they are performed with the necessary care and under strictly uniform conditions) the results obtained for different samples are usually in the same mutual relation as the results obtained by the standard long-time corrosion tests.

For these reasons these rapid tests are more and more frequently used in Europe in all cases where relative data are sufficient, where the properties of the standard types of alloys are known for a datum of comparison, and where the time required for the test is a deciding factor. Such is the case, for instance, when the influence of a given manufacturing process on the corrosion resistance of a given alloy must be controlled frequently during certain stages, or checked on the final product.

FEDERICO GIOLITTI

Ferrite Banding Due to Segregated Alloying Elements

Special letter to METAL PROGRESS
From A. V. Prohoroff, Met. Eng.
Central Institute of Metals

LENINGRAD, *U. S. S. R.* — The fibrous fracture of forged steel is well known. Its origin is in the segregation of alloying elements and impurities in the primary crystals of steel during solidification of the ingot. Forging or rolling improves the properties of the cast metal, but also introduces a directional effect, wherein the mechanical properties of a test piece whose axis is parallel to the principal elongation are different from those of one cut transversely. Often the impact value and elongation in tension of the latter are only half those of longitudinal test bars. While some steels are more sensitive to these effects than others, it seems that the best practice in the production of high strength forgings is to use reductions close to one-third of the original ingot, always insuring proper fiber flow in accordance with the direction of stresses to which a forging will be subjected in service.

If a fibrous fracture is squared, polished and etched with a cupric reagent, so-called primary banding is developed by selective deposition of copper on areas low in segregate. Such primary banding closely corresponds to the fiber seen in a fracture and, being due to persistent dendritic segregation of slowly diffusing elements, can be found in every steel and is little affected by carbon content and ordinary heat treating operations.

Segregation of carbon is frequently revealed by etching a polished sample of slowly cooled steel with ordinary reagents such as nitric acid in alcohol. This is variously termed "ferrite banding," "ghost lines" or "secondary banding." These may or may not be related to primary banding. Rapid cooling through the critical range usually suppresses this appearance. If the steel is annealed long enough and high enough to coarsen the austenitic grain, secondary banding is suppressed, even after slow cooling, but will reappear when the grain is refined.

Since ferrite bands frequently contain slag inclusions (although visible slag may be entirely absent, or contained exclusively in the pearlitic regions) this secondary banding was early ascribed to nucleation of ferrite crystals by persistent non-metallics, or to the segregation of phosphorus or oxygen. Little attention has been

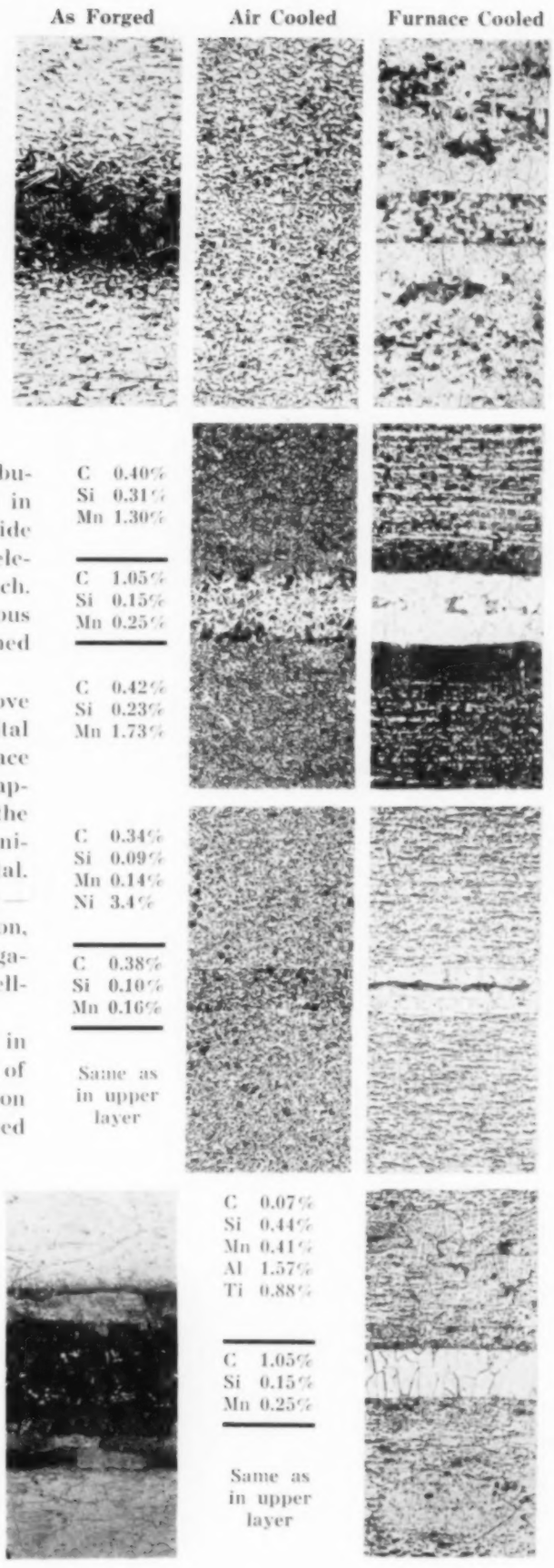
given to the presence of other alloying elements which also segregate in the ingot and diffuse very slowly at working temperatures, or to the suggestion made in 1916 by Henry Marion Howe that the ferrite may form first because the A_3 point was raised in that location by phosphorus (or other appropriate elements).

For these reasons the present writer investigated the influence of some of the alloying elements on carbon migration during slow cooling through its critical range. Thin sheets of carbon steel (36 gage) were sandwiched between alloy steel plates and forge-welded, proper precautions being taken to prevent carburization or decarburization of the faying surfaces in the operation. Chemical analyses are given alongside the accompanying micrographs; in all cases other elements were present in quantities less than 0.02% each. Duplicate samples were then heat treated in various ways, cross-sectioned, polished, etched and examined under the microscope.

After holding 60 min. at a temperature well above the upper critical, no banding was revealed by the nital etch in properly quenched samples, the whole surface having a uniform martensitic structure. It would appear, therefore, that this time is enough to allow the high carbon in the central strip to become almost uniformly diffused into the adjacent lower carbon metal. Air-cooled specimens showed the same feature—namely, approximately uniform carbon concentration, when allowance is made for such facts as that manganese steel has a sorbitic appearance rather than well-defined pearlitic microstructure.

Extremely interesting phenomena occurred in specimens left in furnace to cool slowly at a rate of about 4° C. per min. Considerable carbon migration took place, leading to the formation of very pronounced ferrite bands both in the area of the welds and in the body of the surrounding metal. This migration, leading to a non-uniform distribution of carbon on slow cooling from Ar_3, may be conveniently termed "accumulation" to distinguish it from "diffusion." Diffusion tends to create uniform carbon concentration, and, starting at Ac_1, takes place in the hot austenite between A_3 and A_1. Evidently, the reverse action, or carbon accumulation, may occur only after diffusion has preceded it.

The micrographs on this page, all at 100 diameters, show that ferrite bands are rich in silicon and low in manganese and nickel. (In the top set, for instance, the high carbon insert



has given up its carbon to the surrounding metal, but during furnace cooling some of it has accumulated in about the same region as the original insert, and much of it reappears at some distance away, separated by a carbon-free layer of iron containing about 1% silicon.) It is worthy of note that of these three elements, silicon raises the A_1 to A_3 critical range of steel, whereas manganese and nickel lower this range sharply, and the present writer, following Howe's suggestion, believes this to be the essential point.

It has been suggested that ferrite banding is associated with the power to form stable carbides. This seems to be controverted by the fact that silicon and nickel promote graphitization, whereas manganese has carbide-forming tendencies, and these facts cannot be harmonized with the appearances in the micros.

However, in the presence of sufficient quantities of an element that forms very stable carbides, the re-accumulation of diffused carbon may be partly or totally prevented by the formation of carbides that go out of solid solution at high temperatures and do not take any part in the processes that occur on subsequent slow cooling. This is illustrated in the lowest set of micros, where the results of experiments with alumino-titanium steel are shown. Titanium (like silicon and aluminum) raises the critical range of steel considerably, but, at the same time, it forms carbides stable at very high temperatures. A sample quenched in water from 1750° F. (not in the engraving) shows that the locus of the original 1.05% carbon steel sheet is now occupied by a layer of ferrite, completely carbon-free. All of the carbon initially present in this central strip diffused at the soaking temperature into the adjacent titanium steel and precipitated there at that temperature in the form of stable titanium carbides. These two processes (carbon diffusion and titanium carbide precipitation) continued until there were no free carbon atoms left in solid solution and, therefore, no carbon accumulation back into the purer central band could take place. However, a persistent carbide segregation was developed at the weld.

Now, what is the force that throws carbon atoms in a slowly cooling piece of steel from one location to another, causing its segregation in bands which are the last to transform? Evidently, it is the atomic force of rearranging the crystalline lattice. Small carbon atoms, being located in interstices of the gamma-iron lattice, can move rather freely and, after a comparatively short period of time at a suitable temperature, come to a rather uniform distribution throughout the mass. But the much bigger atoms of silicon, manganese, nickel and many other elements go into solid solution by substituting themselves for iron atoms in the lattice, and being very slow to diffuse cause persistent dendritic segregation. Hot work deforms these dendrites and produces primary banding. Bands or layers of metal, different in composition, have different critical ranges and rates of transformation in spite of a rather uniform carbon concentration (which they may have after soaking a sufficient time at some temperature above A_3). Carbon solubility in alpha iron is very low, and after the beginning of the gamma-to-alpha transformation in bands having a higher A_3 point, carbon is forced out of them and migrates into other regions of metal that still remain in the austenitic condition and can dissolve some more of this element. Ferrite and pearlite bands are thus formed on slow cooling. Carbon accumulation, as well as diffusion, is a time-taking process and can be prevented by sufficiently rapid cooling through the critical range, but its cause — primary banding — is not affected by this treatment and can be revealed by etching with a copper reagent.

The same process of carbon accumulation (the converse of diffusion) is also responsible for the formation of the ferrite and pearlite grains seen in a transverse section of a hot-worked bar, as far as these grains represent the cross-sections of ferrite and pearlite bands. The size and arrangement of ferrite and pearlite areas both in the longitudinal and transverse sections of a hot-worked bar therefore depend on the size and composition of primary bands and on the rate of cooling.

Inert non-metallic inclusions (which are not able to dissociate in a solid steel and to contaminate it with some elements) segregating in inter-dendritic spaces together with other impurities and alloying elements, probably do not exert any influence on the process of carbon accumulation. Their occurrence in ferrite bands, on the one hand, or in pearlite bands on the other, is determined by the effect of other segregates in certain regions in the steel. Thus, if inter-dendritic spaces are rich in elements that raise the critical points (such as phosphorus or silicon) inclusions are found in ferrite bands, but if the main segregate is an element that lowers the critical points (such as manganese) inclusions are located in the pearlite bands.

Future investigations will have to show why carbon accumulation and ferrite banding do not appear when very large austenitic grains are present in a slowly cooled piece of steel.

On the basis of the present investigation and of some practical observations, it is suggested that ferrite banding may be suppressed and the directional effect of primary banding on the physical properties reduced by balancing the composition of a steel so that those alloying elements that segregate in inter-dendritic spaces would oppose each other in their influence. This is the case with some silicon-manganese steels.

A. V. Prohoroff

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Physical Constants of Pure Iron

as determined by The National Physical Laboratory of England on "Batch 5 Iron" except as noted

Analysis :

	Batch 5	M	X
Carbon	0.0045	0.010	0.01
Silicon	0.0002	0.030	0.003
Sulphur	0.0015	Tr	0.0015
Phosphorus	0.0010	0.014	0.003
Nickel	0.0006	—	0.02
Aluminum	Tr	—	—
Magnesium	Tr	—	—
Manganese	0.002	Tr	—
Hydrogen }	<0.001	—	—
Nitrogen }		—	0.002
Oxygen	0.0005	0.05	?

Batch 5 analyzed "nil" for : copper, chromium, calcium and molybdenum. "Slight trace" of boron reported in spectroscopic analysis, and the following elements sought for without result : cobalt, tin, vanadium, titanium, arsenic, barium, gallium, sodium, lead, strontium, tungsten and zinc.

Tensile Tests on ¼" cylinders (coarse grained)

Sample :	A	B
Proportional limit, psi.	4,600±	5,400
Ultimate stress, psi.	26,700	20,400
Reduction of area, %	100	100
Elongation on gage length, %	49	36
Modulus of elasticity, psi.	29.7×10^6	28.0×10^6

Malleability: Cold rolled 99% without anneal.

Hardness; Unannealed Casting

5mm. ball, 250kg. load, 56.5 Brinell
2mm. ball, 40kg. load, 54.5 Brinell
2mm. ball, 20kg. load, 54.0 Brinell

Annealed to Large Crystal Size

2mm. ball 20kg. load, 49 Brinell
Diamond pyramid, 10kg. load, 48

Density: 7.871 ± 0.002 at 19°C.

Melting and Transformation Points:

Melting Point (M) 1527°±3°C., 2781°±5°F.

Delta to Gamma (X), by thermal analysis

Ac_4	1398°C.	2548°F.
Ar_4	1397°C.	2547°F.

Alpha to Gamma (X), by dilatometry

Ac_3 range	924 to 950°C.	1695 to 1742°F.
mean	937°C.	1719°F.
Ar_3 range	917 to 905°C.	1683 to 1661°F.
mean	911°C.	1672°F.

Magnetic (Curie) Point (X), by thermal analysis
Ac_2 769°C., 1416°F. Ar_2 767°C., 1413°F.

Magnetic Permeability: 14,360 at 0.5 oersted

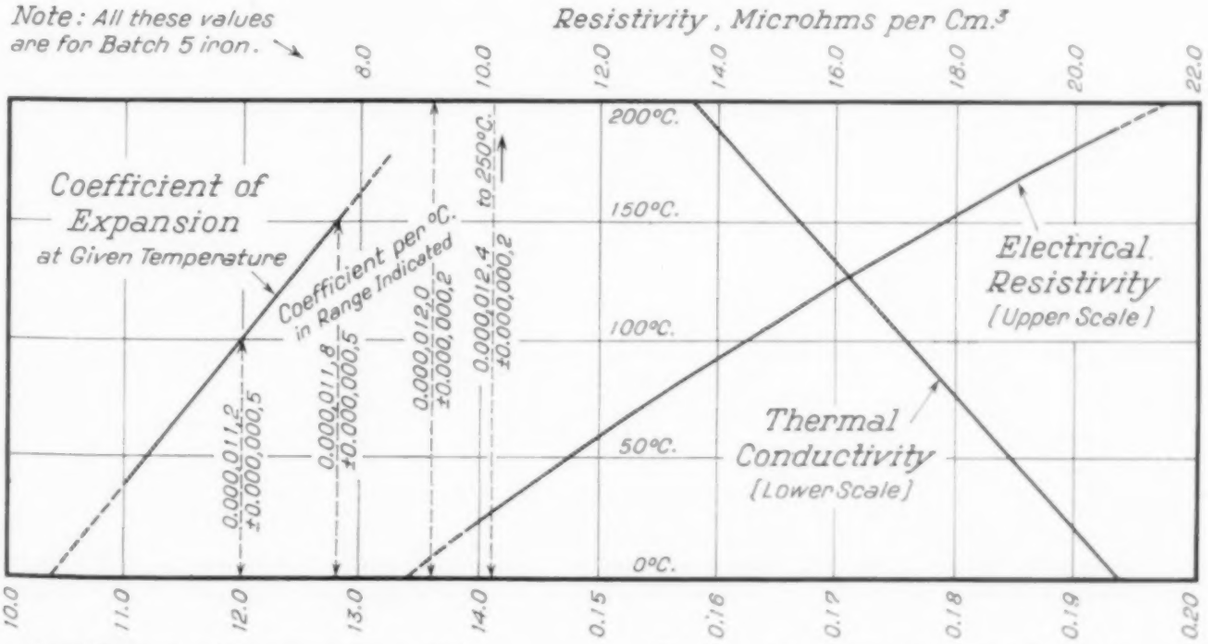
Remanence: after 15 oersteds, 8,700 gauss

Coercivity: after 15 oersteds, 0.27, oersteds

Lattice Parameter: alpha iron at 17°C. (body centered cubic) 2.8600Å ± 0.0005Å

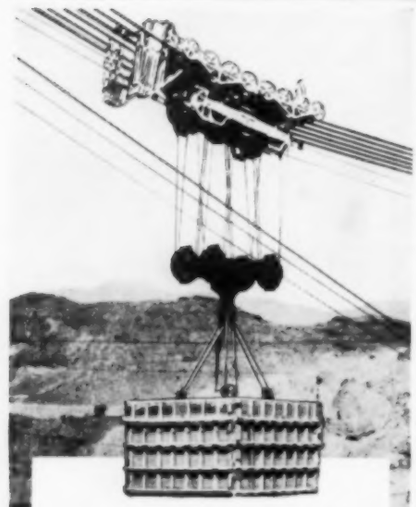
All data selected from "Physical Constants of Pure Metals" H.M. Stationery Office, 1936

Note: All these values are for Batch 5 iron.

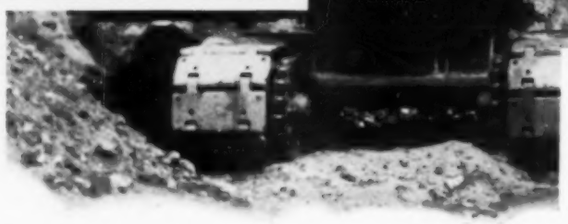


THE METALS THAT CONQUER NATURE...

are needed in EVERY plant!



● Here is the cableway that was used for lowering materials down to the bed of Boulder Dam. Nickel Alloy Steels helped to make it the strongest ever built. ...150 tons capacity. When weight must be held down, the ordinary steels have limitations. Here's where the Nickel Alloy Steels come in. Their high strength-weight ratio accompanied by unusual toughness makes it possible to construct machinery for the heaviest duty without increasing the weight of vital parts.



● Power shovels must take everything that comes their way. No machinery fights a more bruising battle, takes more shocks, stresses, wear. If you are using or building equipment that requires stamina to spare, take a tip from the makers of excavators. Their standard practice is to make liberal use of Nickel Steels and Nickel Irons for parts that get the hardest usage. Because of their high resistance to stresses and wear, replacements are seldom necessary.

● This reamer helped to dig one of the deepest oil wells ever drilled — more than two miles deep. Picture it grinding through rock, shale, earth and sand! Heavy abrasion all the way, and heavy shocks too. But they mean little to this husky tool because it is made of wear-resisting, shock-defying Nickel Alloy Steel. Perhaps you have a gear or a shafting problem that has always been troublesome. Here's your answer, no matter what the job. The long-run economy of the Nickel Alloy Steels and other alloys containing Nickel can be quickly demonstrated. Our engineers will be glad to advise you concerning applications and compositions best suited to your requirements.

NICKEL ALLOY STEELS

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL ST., NEW YORK, N. Y.

By Raymond L. Collier
Secretary
Steel Founders' Society of America
Cleveland

Strong steel castings ride the rails

STEEL CASTINGS mean to the railroads what structural steel means to the builders of skyscrapers. They are the *sine qua non* of modern railway equipment. Therefore, the advent of the steel foundry industry in the closing decades of the last century was not a "happenstance." It was the answer to an engineering demand — from the railroads — for a material strong enough to withstand the heavy dynamic stresses imposed by accelerated speeds; tough enough to stand up under heavy impact; light enough to furnish the necessary strength and toughness without sacrificing pay load per horsepower.

Steel castings answered these specifications. The steel foundry industry was born.

From the beginning the steel foundries have worked closely with the car and locomotive builders and the superintendents of railway motive power in developing structures that would cut operating costs, promote greater safety, reduce maintenance expense, or otherwise assist in advancing the art of railroading.

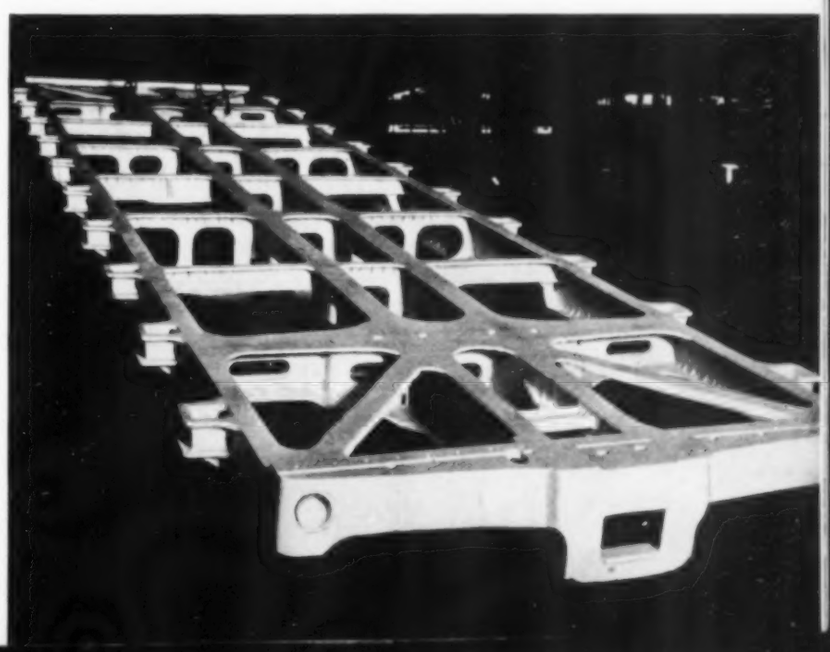
Back in the early days of the industry, heat treatment as it is practiced today was unknown; cast alloy steels were laboratory curiosities; there was no cleaning room equipment worthy of the name. Making a steel casting was an adventure. Few of the laws of steel founding had been discovered. Sand control, heading, gating, molding, pouring and testing were a matter of trial and error. That steel castings made in those days gave such a good account of themselves is a tribute to the patient diligence of the steel foundrymen of that generation, and the inherent good qualities of his medium.

With the advent of scientific procedure, there slowly developed a sound technique of foundry practice. Castings of predictable excellence could be produced—they were no longer the chance product of empirical methods.

Throughout this period of advancement the steel foundries continued to cooperate with the railroads. New plans and ideas were translated into improved devices for rolling stock or right-of-way. Many of these were patented by the foundries by whom they had been *designed* and created. New patents succeeded old ones in rapid order, coincident with the advances made in the art of designing and producing superior, quality steel castings.

Physical specifications were increased again and again. Alloy steels invaded the steel foundry and the railroad field. Different heat treatments were developed which enabled the foundry to furnish steel castings specially preconditioned for their peculiar service requirements. Tolerances on castings to be machined were reduced, heavier members being supplanted by cast steels with higher physicals. Every new discovery by steel foundrymen was

Enormously Long, Wide Steel Castings, Intricately Cross Braced and Bracketed, Form the Complete Underframe of Tenders and Even Freight Cars



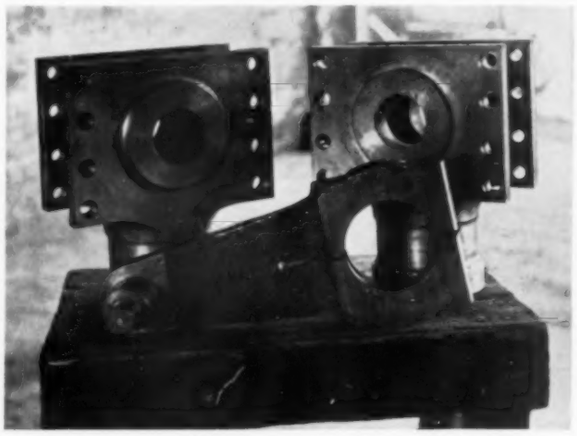
soon applied to the production of more satisfactory parts and equipment for their largest customer, the railroads.

To chronicle fully the innumerable cases in which the steel foundries have successfully answered technical problems of the railroads would be impossible. A few scattered examples, taken at random, may serve to indicate the intimate cooperative relationship that has always existed between these two industries.

Nearly everyone has seen pictures of the old locomotives of Civil War time, that seemed to be all smokestack on top and cow-catcher in front. Despite the technical name "pilot," "cow-catchers" they really were in those days before the right-of-way was adequately fenced and grade crossing elimination not even dreamed of. With passing years, both funnel and pilot have been reduced to vestigial proportions, and the pilot converted from an enormous lattice of wood and wrought iron to a moderate sized fabrication of steel bars and shapes, and more recently into an even smaller one-piece casting. Railroad experience indicates that the integral cast steel pilot is much more rigid, much easier to attach and costs less than its fabricated predecessor. It is a good example of where impact resistance (toughness) is a matter of prime consideration.

The halftone in the next column shows two crossheads and one cast steel crank arm. These members were formerly made of plain carbon steel castings and forgings. Recently they were successfully converted into manganese-vanadium alloy cast steel. The purchasing railroad requires the following: No welding must be used; castings must receive a dual heat treatment (a preliminary heat treatment before cleaning and a final normalize and draw after the castings have been cleaned) so as to insure uniform grain structure throughout. The crosshead, of course, joins the piston to the connecting rod. The crank shown is bolted to the protruding end of the crank pin on the main driving wheel, and its smaller end forms the eccentric for driving the valve gear — a vital engine part which must withstand alternating dynamic stresses.

A good many things on a locomotive might crack up or fail in service without serious consequences. Not so with the driving wheel. Time out of mind, driving wheel centers have been steel castings. Comparatively new developments in this field are the modern double plate or box-sectioned wheel and the so-called disk type driving wheel with which many of the latest locomotives have been equipped. The figure on the opposite page shows an example of the latter. Both types were created to solve the problem of properly counterbalancing the wheels against dynamic augment, a matter of increasing importance, what with increasing locomotive speeds which would otherwise damage the rail and rack the locomotive, resulting in increased maintenance on right-of-way and higher locomotive repairs.



Cast Crossheads and Valve Gear Lever Made of Heat Treated Manganese-Vanadium Steel Are Replacing Plain Carbon Steel Castings and Forgings in Present-Day Locomotive Construction

Advantages claimed for the new disk type wheels are as follows:

1. By reason of the reinforcement ("backing-up") provided by the disk and by the triangular sections (double plate) at the rim and hubs, it is possible to reduce the axle and wrist pin hub diameters, thus lightening the crank pin half of the wheel and affording more space in the other half for counterbalance. This not only improves the balance but also increases its effectiveness due to the reduction of weight of the half of the wheel carrying the crank pin.

2. High rigidity of the rim, which is obtained from the supporting walls of the double plate of the rim structure.

3. Axle and crank pin hubs are very rigid in the radial direction by virtue of the double plates immediately adjacent to them.

4. The large openings in the body of wheel afford maximum access for lubricating and inspecting hub liners, shoes and wedges and also permit easier removal of wrist pins.

5. In many cases it is possible to decrease the total weight of the wheel as compared with

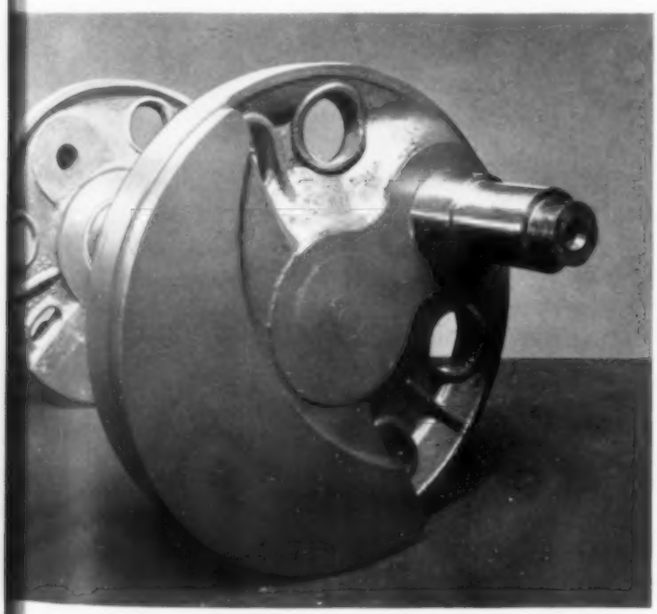
the solid spoke type wheel, thus effecting a reduction of the total unsprung weight of the locomotive.

6. These improved wheels have a pleasing, symmetrical appearance.

With these newer types of wheels, it has been possible to secure in some cases a reduction of as much as 40% in dynamic augment at all speeds. This result was accomplished by reducing the unbalanced forces from those existing in the solid spoked wheel, some of this difference being obtained by cross balancing.

Thus it can readily be seen what a tremendous improvement is made, not only in the reduction of track stresses, especially at the higher speeds, but also in the reduction of locomotive maintenance. High maintenance charges are inevitable where locomotives are operated at speeds greater than that for which their counterbalance was calculated. This shows up in rapid development of "pound" in driving boxes, and wear of shoes and wedges, rod brasses, crank pins and axle journals. These modern driving wheels provide the answer to many problems and permit old motive power, so equipped, to be operated at speeds hitherto unsafe, and even impossible.

Many new locomotives are equipped with spring hangers made of heat treated vanadium steel castings rather than forgings of similar design. They have given complete satisfaction with a material reduction in cost. Average analysis of these castings will run: Carbon 0.25%, manganese 0.60%, silicon 0.30%, phosphorus 0.035%, sulphur 0.04%, and vanadium 0.12%. They are quenched and drawn to give the following physical properties: 45,000 psi. elastic limit, 80,000 psi. ultimate strength, 30% elongation, and 45% reduction of area.



A Pair of Driving Wheel Centers, With Axle and Crank Pins Mounted. This design is carefully worked out, not only for strength, but for counterbalance both radially and crosswise at the higher speeds demanded by 1937 traffic

Corrosion Resistance

In the construction of freight and passenger cars and locomotive tenders the part played by cast steel is equally impressive. One of the most interesting characteristics of steel castings in this application is their remarkable resistance to corrosion. This is a quality which, though conclusively demonstrated in actual practice, has not been generally appreciated.

A couple of interesting examples will furnish convincing testimony:

The tender underframe, which is the connecting link between the locomotive and train, and therefore a structure subjected to great tensile and compressive stresses, coupled with enormous impacts, is the foundation for a traveling storehouse for coal and water. Forty years ago, tenders were small, with wooden underframes. As their capacities for water and fuel increased, wood was found inadequate and rolled steel was substituted. Corrosive action, resulting from the combination of coal spillage and leaky tanks, quickly manifested itself in high maintenance, particularly around the draft sills and bolsters. Cast steel truck and underframe parts (which had come into quite general use during the early years of the century) suggested a remedy.

In 1907 two cast steel tender frames were made for the Central Railroad of New Jersey. One of these had the center sills, bolsters and draft sills of cast steel with rolled steel side and end sills riveted thereto; the other had the entire foundation as a one-piece casting. While the cast steel portion of the composite frame stood up splendidly in service, the rolled sills were replaced more than once.

The one-piece frame therefore quickly demonstrated its superiority. After 20 years of continuous use, these two frames were removed from service to form part of an historical exhibit maintained by one of the large steel foundries. No noticeable deterioration had taken place in all that time, despite *(Continued on page 198)*

The electric furnace —its influence on civilization

By P. H. Brace
Research Engineer
Westinghouse Electric & Mfg. Co.
East Pittsburgh

THE ELECTRIC FURNACE had its inception in experiments made by Sir Humphrey Davy in 1800. Volta, a short time before, had discovered the primary cell, and Davy used a large battery of these to produce an electric arc between charcoal electrodes.

In 1815, one W. H. Pepys passed current from a primary battery through an iron wire in which a cavity had been made and filled with diamond dust. The iron, heated by the electric current, absorbed carbon and became steel. Thus a question of the day as to the nature of steel was answered and carburizing first done in an electric furnace.

Despretz followed in 1849 with experiments on the fusion of refractory substances in an electric arc, again using power derived at great expense from primary batteries.

In the footsteps of these pioneers and after dynamo-electric machines became available in 1867 there were organized numerous companies which sought to apply the electric furnace in a practical way.

We will confine our attention to the metallurgical field, and pay our respects to Siemens for his direct and indirect arc furnaces for metal melting (1867); Heroult and Kjellin (1900) for successful attempts at making steel in electric furnaces; Moissan (1903) for his classic researches on high temperature reactions in arc-heated furnaces, which sowed seeds of knowledge and technique from which have grown industrial enterprises of first magnitude; the Americans, Colby (1890), for successful core-type induction furnaces and Professor Northrup of Princeton (1916) for the high frequency coreless furnace, the installed capacity of which amounts to approximately one-sixth of all electric furnaces in the United States.

Attention will now be directed to the effects of metallurgical electric furnace technique upon our ways of living.

According to our modern ideas the structure and properties of all matter are dependent upon the magnitude and disposition of electrical forces. These determine first how the atoms themselves are built and second how the atoms are disposed with respect to one another in compounds. Electric forces and temperature, applied singly or in combination by means of electric furnaces, are potent means for effecting desired rearrangements of the atoms which make up our world.

Not so long ago there was quite a number of metals whose existence was known to chemists, but which were not available in pure form in industrially useful quantity because there were no economical means for separating the metal atoms from the non-metallic partners assigned them by Nature. It will be instructive to coasider a short list of metals which have become available for industrial usefulness as a result of electric furnace technique, together with notations as to their spheres of usefulness.

Aluminum is an outstanding example, of course, because of the facts that its isolation requires the breaking of a particularly strong association of the element with its natural partner, oxygen, that heat and electric forces to-

A paper presented before the Electrochemical Society, Niagara Falls, Ontario, October 8, 1936

gether must be brought to bear, and that its fortunate combination of properties makes it useful for its own sake and as well as a very potent reagent in the preparation of other metals. (Footnote 1.) Its lightness, the ease with which it may be shaped, its pleasing color, high electrical and thermal conductivity, the strength of some of its light alloys and the fact that protective oxide films form on its surface and protect it against many corrosive influences, have brought aluminum into a prominent place in our civilization.

As cooking utensils, in paint, in long-distance power transmission lines, in aircraft structure and power plant, in candy wrappers and furniture, aluminum bears quite directly upon our manner of living.

Magnesium is another light element which is available by virtue of the electric furnace and which is being marketed on an increasing scale in the form of castings, forgings, and sheets. (Footnote 2.) The addition to magnesium of small amounts of other metals, aluminum and manganese for example, provides magnesium alloys which are susceptible to heat treatment and which have strength-weight ratios approaching those of the high tensile steels. Magnesium has a hexagonal crystal habit which causes it to respond somewhat peculiarly to plastic deformation, a fact that has somewhat hindered its application in wrought forms. However, these difficulties are being overcome and the use of magnesium in wrought as well as cast forms is steadily increasing. (Footnote 3.)

Beryllium is a name much conjured with. This metal is available as such and in the form of alloys by way of fused salt electrolysis. It has found considerable favor as a strengthening element for copper. Copper base alloys having beryllium contents ranging from approximately 0.5 to 2.5% are responsive to heat treatment. Relatively high hardness, good ductility and high resistance to fatigue and corrosion characterize properly heat treated beryllium-copper alloys and the relations among the various physical properties are sufficiently novel and useful to have secured a place for these new materials in the "active" list of engineering alloys. Beryllium metal is lighter than aluminum, and has a relatively high melting point (approximately 2400° F.), an elastic modulus almost as high as that of steel, and expansivity of the same order as that of steel. If this combination of properties could be secured in conjunction with good ductility and moderate cost we might witness another revolution in structural engineering such as that brought about by the advent of heat treatable aluminum alloys and high strength corrosion resistant alloy steels. (Footnote 4.)

Metals as such are in general not particularly stable materials unless well cared for because of their susceptibility to corrosion. As

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Footnotes by the Editor: (1) The electric process for the production of aluminum, previously a rare metal, was discovered by Charles Martin Hall in Oberlin, Ohio, in 1886, by the electrolysis of alumina dissolved in a fused bath of cryolite. It had previously been made by an expensive chemical process. See "Contributions of Aluminum to Metallurgical Progress" by Junius D. Edwards, **Metal Progress,** February 1936, page 35.

(2) Magnesium was first produced electrolytically by the great German chemist Bunsen, who electrolyzed fused magnesium chloride, and commercial production along these lines began over there in 1886. The American industry was a War baby, the survivor of which is Dow Chemical Co. of Midland, Mich. For a fascinating account of the growing pains at this plant see "Magnesium, the Growth of an American Industry," by John A. Gann, **Metal Progress,** April 1932, page 33.

(3) **Metal Progress,** October 1934, page 43 and October 1935, page 123.

(4) Beryllium, or glucinium as our English cousins have it, was isolated by Wöhler more than 100 years ago, but intensive study with a view toward commercial development did not occur until 1919, when Alfred Stock and Hans Goldschmidt organized a research in Germany, which has resulted in commercial production by Siemens and Halske by the electrolysis of a fused mixture of beryllium oxyfluorite, barium fluoride and sodium fluoride. See "Beryllium, Its Production and Applications," translated by Richard Rimbach and A. J. Michel, published by Chemical Catalogue Co., New York. In this country research work has been continuously under way for 15 years by the Brush Laboratories of Cleveland. C. B. Sawyer, now head of Brush Beryllium Co., informs the Editor that commercial production is under way at Lorain, Ohio, making a beryllium-copper "master alloy," prices recently having been reduced from $30 to $23 per lb. of contained beryllium. Dr. Sawyer is also authority for the statement that "beryllium-copper alloys were originally produced by Lebeau in 1897, but it remained for Corson in the United States to discover their heat hardening capacity in the presence of added nickel. Almost simultaneously, Masing and Dahl in Germany discovered the heat hardening capacity of plain beryllium-copper."

our civilization has developed metals have come to play an increasingly large part in our daily lives in the form of tools, means of transport, communication, sanitation, and shelter. Consequently, corrosion has come to be an increasingly important negative factor in our economic structure.

Chromium in industrial quantity is an electric furnace product and to this metal are due the useful properties of a number of alloys which touch the routine of our lives quite closely because of their resistance to corrosion. (Footnote 5.)

Practically all electric heating appliances such as warming pads, irons, toasters, ranges depend upon metallic heating elements which by virtue of the fact that they are made from alloys containing considerable proportions of chromium, are able to resist the attack of oxygen even at a bright red heat. Electric resistance furnaces for the heat treatment of metals, and a host of special industrial heating devices depend upon chromium alloy heating elements. Quite recently new alloys comprising both chromium and aluminum have been developed which are capable of operating at considerably higher temperatures than the previous heat resisting alloys adaptable to industrial use. This development in the "dry" corrosion field is expected to greatly widen the field of usefulness of electric resistance furnaces. (Footnote 6.)

The foregoing chain of circumstances may be summarized by saying that electric furnaces themselves have been made possible by metals of electric furnace origin!

In the "wet" corrosion field chromium again figures as the key metal in a number of iron-base alloys developed during the last 25 years by a number of investigators in various countries, headed by Harry Brearly in Sheffield, and which are grouped under the blanket heading of "stainless steels." In the form of kitchen cutlery, trim on automobiles, architectural details on modern office buildings, and various art forms as exemplified in modern home furniture and ornament, chromium alloys of electric furnace origin are a factor in the daily life of our time. A recent estimate by E. F. Cone, places the value of 1936 production of stainless steel alone at approximately $50,000,000, and the trend is rapidly upward.

The fast and beautifully formed modern airliner and the transoceanic dirigible are the gift of the electric furnace. Aluminum, chromium, tungsten — all of electric furnace origin — combined in various ways with iron, copper and other metals, frequently by means of the electric furnace, make possible the light, strong, corrosion-resistant alloys of which to build the sleek, man-made birds and the light and powerful motors which drive them 200,000 route-miles a day over the airways of our country alone.

Tungsten, the most refractory of the metals, won from its compounds and brought to shape as filaments in electric lamps by methods in which electric furnaces and electric heat play a vital part, brought a new era in artificial illumination because it could withstand the high temperatures necessary to provide light of pleasing quality and high efficiency. (Footnote 7.)

Two of the fundamental problems in the creation of structures are the shaping and the joining of the parts.

The electric furnace within the past ten years has made possible revolutionary advances in the shaping of materials by reason of its use in the manufacture of extraordinarily hard materials of which tungsten carbide is an example. The elaboration of these basic substances into cutting tools and dies and a variety of other special products again *(Continued on page 188)*

(5) Chromium is a peculiarly American alloy. Chromium steel was first made in the crucible, and commercially since 1869 when Julius Baur established the Chrome Steel Works in Brooklyn. Moissan's laboratory work between 1892 and 1895 included many reductions of chromium in a tiny electric furnace, but large scale experimentation by De Chalmot at Spray, North Carolina, in 1896 led to the establishment in 1897 of the commercial plant still operating at Holcomb Rock, Va. F. M. Becket has been intimately connected with many recent developments (see **Metal Progress,** September 1935, page 54).

(6) Albert L. Marsh discovered in 1905 the family of ductile alloys containing more than 75% nickel and less than 25% chromium which had high electrical and oxidation resistance, and on which most electrical heaters depend. An account of this discovery is printed in **Metal Progress,** May 1935, page 41. More recent developments are described in "A New Resistor Alloy — Chromium-Aluminum-Iron" by S. L. Hoyt, **Metal Progress,** July 1935, page 38.

(7) See "Powder Metallurgy as Illustrated by Tungsten" by W. P. Sykes, **Metal Progress,** March 1934, page 24; "Developments in Cutting Tools — Alloy 548" by Zay Jeffries, **Metal Progress,** February 1933, page 29; "Hard Facing Materials and Methods" by R. E. Brown, **Metal Progress,** October 1935, page 136.

SAVE

HOW MUCH DOES THE TELEPHONE ~~COST~~?

It is easy to figure how much the telephone costs. It is not easy to reckon how much it saves.

A single telephone call may save a life—brighten a friendship or a day—sell a bill of goods or land a job.

One telephone call may be worth more to you than the cost of the service for months and years to come.

The telephone saves you priceless hours of time each week—spares you trips through snow and storm these uncertain winter days.

Without moving from the warmth and comfort of your own fireside, you are in touch with stores and friends and office—by telephone. The cost is but a few cents a day. In return, the telephone offers you increasing measure of security, convenience, happiness and achievement.

Every time you call a number, you use some part of a nation-wide telephone system that cost more than four billion dollars to build and employs about 300,000 people. The facilities of this entire organization are yours to command—anywhere, any time, and at small cost.

BELL TELEPHONE SYSTEM

Electric furnaces in modern metallurgy

(Cont. from page 186) required the electric furnace. The cost of gasoline and of the car it propels have both been minimized by the use of these super-hard alloys from the electric furnace for oil-well drills on the one hand and metal-working tools on the other. We now run metal working machinery at cutting speeds approaching those used by the woodturner not so many years ago.

In connection with the building of things I take the liberty of mentioning an electric furnace product of non-metallic character that has had a profound influence on the art of working metals. I refer to calcium carbide which is a typical electric furnace product in that we know no other means for producing it on an economically useful scale. (Footnote 8.)

From calcium carbide (a product of intense heat) is derived acetylene which when brought together with oxygen (distilled from air at temperatures near absolute zero) in a suitable torch provides a flame hot enough to "cut" steel — I may almost say "machined" into complicated shapes with considerable precision and the greatest of ease. These shaped parts may then be joined by means of a welding arc (which may be regarded as a mobile electric furnace which melts, refines, and casts the jointing metal) to form structures of all sorts, even as large as the frame of a huge turbo-generator or the gates of Boulder Dam. Electric furnace technique applied by way of the cutting torch and the welding arc makes it almost as easy, in a physical sense, to build of steel as of wood and the effects upon the structural art have been revolutionary.

Silicon, although not strictly speaking a metal, is nevertheless so closely associated with metallurgical art and so dependent upon the electric furnace for its existence in the free state that it seems proper to include it in this discussion. From sand and coke, under the influence of electric heat, emerges the element silicon, sometimes alloyed with iron or other metals and again in an almost pure state, to take its place in the intense drama of a civilization whose very existence depends more and more on the application and control of materials and forces scarcely dreamed of a generation ago.

The principal use of ferrosilicon is as a deoxidizer for steel castings (where it is universally used) and for steel ingots (where it shares honors with ferromanganese and aluminum). Silicon as an alloying element is a vital component of metals so diverse as gray cast iron, and electrical sheet. The latter is the magnetic material composing the cores of the generators and of the series of transformers through which power from the generating station must pass as its voltage is successively stepped up for long-distance transmission and down again for distribution to shop and home. The size, cost and efficiency of these indispensable links in our electrical network are so favorably influenced by the use of electric furnace silicon and specialized electric furnace heat treatment in the manufacture of their magnetic parts that we may credit economies to this phase of electric furnace technology great enough to have a favorable and definite effect on our electric light bills.

In structural steel, silicon contributes to high elastic strength at low cost and enables the construction of lighter and stronger bridges, ships and other large structures. In the springs of a large proportion of today's automobiles are found alloy steels in which high elastic properties have been obtained at moderate cost by the use of substantial quantities of one or more of the elements silicon, chromium, manganese, molybdenum and vanadium, all of electric furnace origin.

Heating Furnaces

So far the use of electric heat and the electrically heated furnace as a processing tool has not been mentioned, other than by inference in speaking of the chromium-nickel resistors. At the outset of such consideration it should be noted that electric heating furnaces have been developed to such a point that they may be regarded as machine tools, quite a different conception than one has of those erections of brick, crude structural iron and dirt that the word "furnace" often conveys. The mechanization of furnaces has been made possible by the

(Continued on page 194)

(8) Edmund Davy in 1836 told the British Association about acetylene gas, but its commercial possibilities lay latent until 1892 when the Americans Willson and Morehead produced calcium carbide in an electric furnace. For an appraisal of the present acetylene industry, see **Metal Progress**, February 1936, page 33.

SINEWS FOR SERVICE

IF THE service is tough — so are Moly irons and steels. Take slush pumps in the oil fields . . . driven continuously and operating under severe conditions.

Since no pump is better than its parts, many pump builders use Moly irons and steels for the vital parts . . . because they have proved their capacity to withstand the toughest going.

One manufacturer, for example, uses carburized Nickel-Moly (SAE 4615) for pump cylinders. It was selected primarily because it takes a case impervious to the abrasion of well cuttings; and pressure is always constant. Minimum distortion from heat-treating was also a factor. . . . Just one of many cases where Moly steel or iron has settled a difficult problem — to the mutual advantage of the manufacturer and the user of the product. From either standpoint, Moly steels and irons will prove well worth their investigation.

Our technical books, "Molybdenum in Steel" and "Molybdenum in Cast Iron," will be found of unusual interest to engineering and production heads in any industry using or producing ferrous products. A simple request brings either or both — and, if desired, puts your name on "The Moly Matrix" monthly mailing list. Our experimental laboratory facilities are available for the study of any special problem in alloy steel or iron. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

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MOLY

Personal Items

Howard Glenn Smith has resigned from Caterpillar Tractor Co. to take over the chief inspectorship of the Hummer Mfg. Co., Springfield, Ill.

Wilber G. Somes has been appointed manager of sales for Carnegie-Illinois Steel Corp. in the St. Paul-Minneapolis district.

Arthur L. Collins has been appointed assistant sales manager of Horace T. Potts Co., Philadelphia. He will be succeeded as manager of the tool and alloy steel division by **Allan W. Ainsworth.**

L. C. Conradi has been promoted from metallurgist to technical research director of the Endicott plant of International Business Machines Corp.

F. Price Norris, Jr. has resigned from Superior Steel Corp. to become district sales manager for Allegheny Steel Co. with office in Philadelphia.

Philip McCaffery has been promoted from contact metallurgist with Columbia Steel Co. at Torrance, Cal. to assistant superintendent of the blast furnace at the plant in Provo, Utah.

Howard A. Smith has joined the metallurgical staff of the Republic Steel Corp. and will have charge of work on corrosion of stainless steel at the South Division, Canton, Ohio.

Frederick Gardener Cottrell, president of Research Associates, Inc., has been chosen to receive the Washington Award of the Western Society of Engineers for 1937. Dr. Cottrell is famous for his work on production of helium, nitrogen fixation, and the invention of the Cottrell electrostatic precipitator for dust.

Wayne L. Cockrell has been appointed instructor of mechanical engineering at Michigan State College, East Lansing, Mich.

Edward C. Felton has been elected vice-president of the Hunt-Spiller Mfg. Corp.

Pierce T. Wetter has left the staff of the American Society of Mechanical Engineers to become executive vice-president of the American Cutting Alloys, Inc., New York.

W. Paul Eddy, Jr., chief metallurgist, General Motors Truck Corp., Pontiac, Mich., and secretary, Detroit Chapter, is to prepare the American Foundrymen's Association exchange paper for the 1937 meeting of the French Foundry Technical Association.

O. W. Ellis, trustee and director of research in metallurgy, Ontario Research Foundation, is to present the American Foundrymen's Association exchange paper before the Institute of British Foundrymen.

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For the machining of EITHER
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PIECES PER TOOL GRIND
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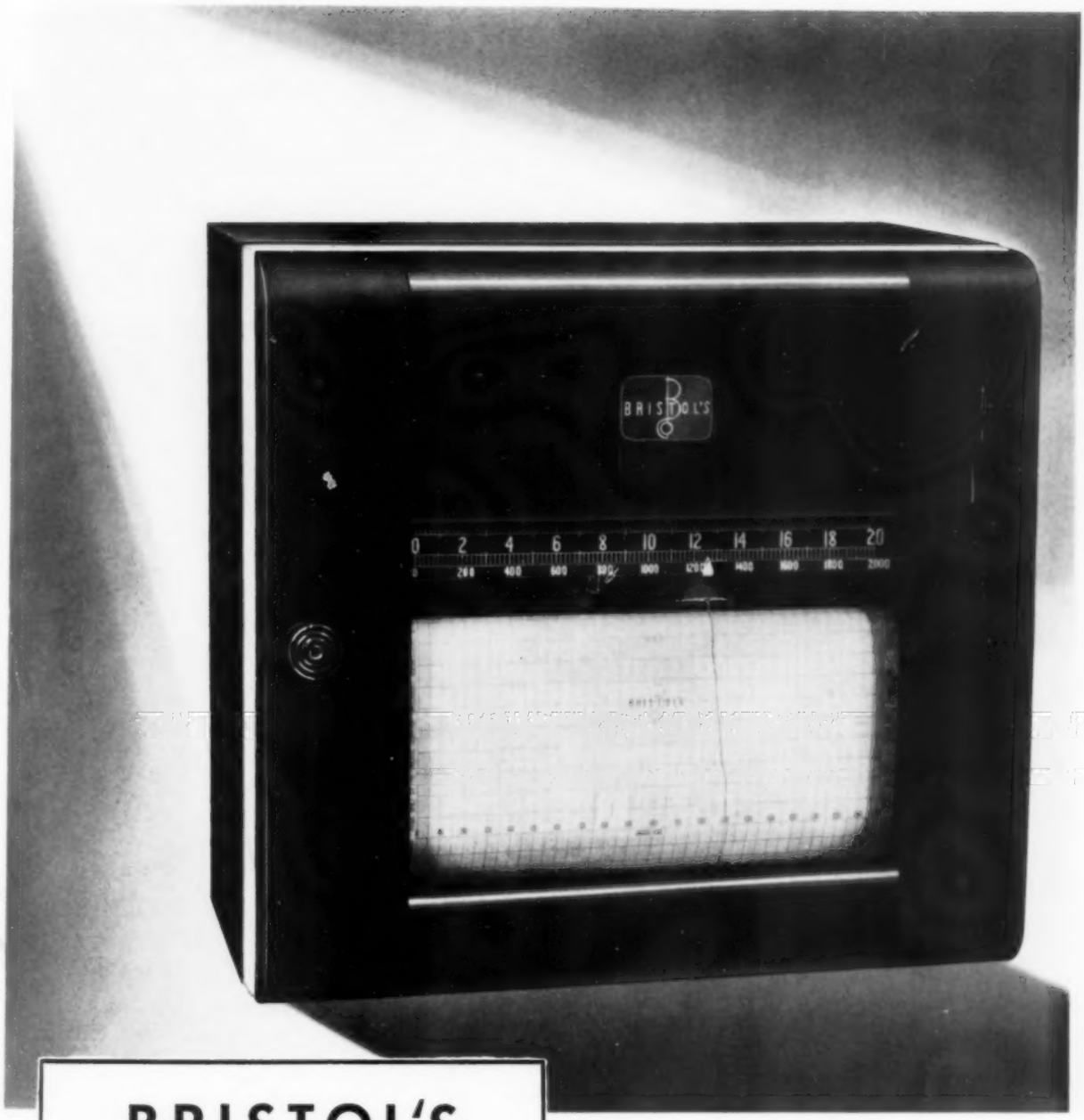

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PIONEERS IN PROCESS CONTROL SINCE 1889

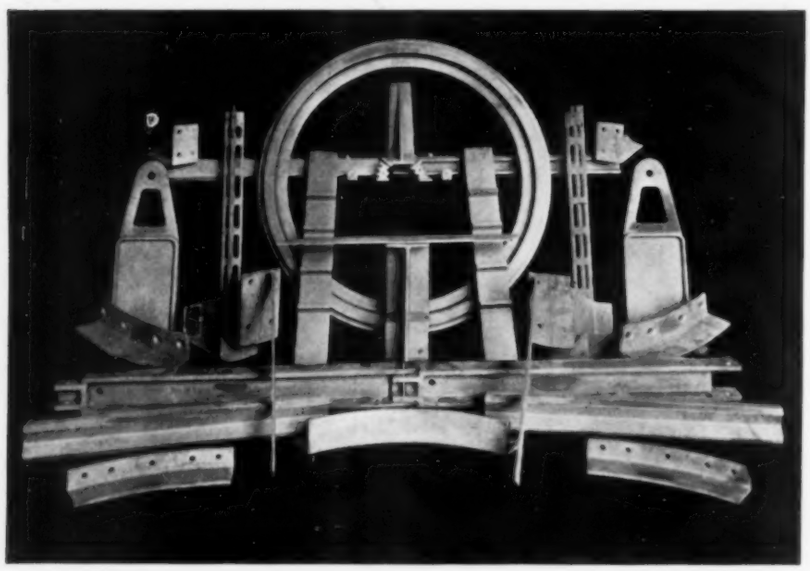
Personal Items

Bruce A. Rogers has been appointed supervising engineer of a new section of the metallurgical division of the U.S. Bureau of Mines to be devoted to the metallurgy of steel.

N. A. Ziegler has accepted a position as research metallurgist with Crane Co., Chicago.

O. W. McMullan is now with the Youngstown Sheet & Tube Co., Indiana Harbor Works, at East Chicago, Ind.

Robert G. Guthrie, past president, and consulting metallurgist for The Peoples Gas Light and Coke Co., Chicago, has been appointed chairman of the Ferrous Metals Committee of the Industrial Gas Section of the American Gas Association.



LONGER LIFE *from* **"*Chromax*" Furnace Parts**

The life of the furnace parts determine the life of the furnace. Long life for the furnace part is assured if the parts are made of "Chromax," the Driver-Harris alloy. The extraordinary strength and heat-resisting qualities of "Chromax" make it well adapted for furnace parts. That is why we say "Longer Life with Chromax."

Why not write for further details? Our engineers are always ready to help solve your heat-resisting problems.

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Chicago Detroit Cleveland England France Italy

A. E. White, professor of metallurgy at University of Michigan and past president, has left for a Mediterranean trip and will be away about two months.

C. F. Christopher, open-hearth superintendent of the Railway Steel-Spring Division of the American Locomotive Co., has also been made chief metallurgist.

C. W. Gordon has joined the Combustion Engineering Co., Inc., Chicago.

Calvin A. Hooker has been appointed representative of the Ajax Electric Co., Inc. in the Michigan and Western Ohio territory. **Edward L. Barker** has been appointed representative in the New England territory.

Willard A. Raiche is a mill representative in the Detroit area for Inland Steel Co.

William J. Jabsen has joined Bliss & Laughlin, Inc., as contact metallurgist.

William Stranberg is now employed in the tool design department at General Electric X-Ray Corp.

John Fulton is now with Wheelock-Lovejoy & Co., Cambridge, Mass.

Richard P. Stemmler is now with the plant metallurgical department at the Newburgh wire works, American Steel & Wire Co.

Frederick G. Sefing formerly assistant professor of metallurgy at Michigan State College, has joined the research laboratory of International Nickel Co., Inc. at Bayonne, N.J., where he will be employed on research work in cast iron. **Charles H. Lindsley** and **Donald J. Reese** have also been added to the laboratory staff.

Richard F. Barnes, Jr. and **Carl Rolle** have been added to the Development and Research Division of the International Nickel Co. in New York, where they will be available for consultation on mill problems.

ANNOUNCING

a new member of a famous insulation family...

JM-20 INSULATING BRICK

...designed for equally effective performance as a back-up insulation behind refractory walls and as an insulating refractory for temperatures up to 2000° F.

HERE'S another product of the Johns-Manville Research Laboratory, the newest member of a famous insulation family . . . JM-20 INSULATING BRICK!

In JM-20 you will find combined every quality that characterizes the ideal insulating brick or insulating refractory—unusually light weight, low conductivity, high heat resistance, ample strength, zero shrinkage at 2000° F., and surprisingly low cost.

Behind refractory walls in hot-blast mains and bustle pipes, in producer-gas mains and open-hearth regenerators, in various types of furnaces . . . or for direct exposure in radiant tube-type annealing furnaces, electric furnaces or wherever there is no flame impingement, slag action or mechanical abrasion . . . JM-20 is ready to establish for itself the same record for maximum effectiveness now enjoyed by Superex Blocks, Sil-O-Cel Brick and the other members of the J-M Insulation family.

Data sheets on the new JM-20 Insulating Brick are now available. For particulars on characteristics and recommended uses, mail coupon to Johns-Manville, 22 E. 40th St., N.Y.C.

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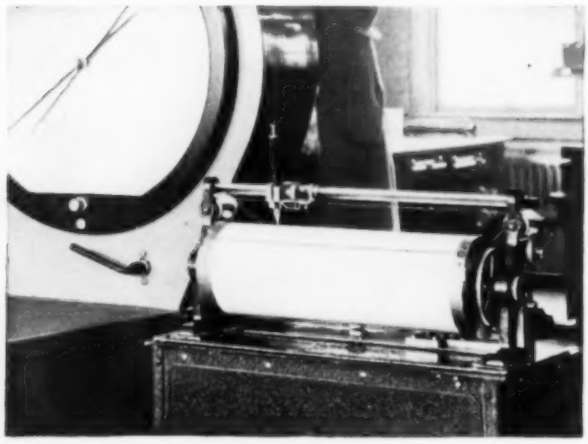

The Southwark-Templin Stress Strain Recorder is an instrument for automatic production by electro-mechanical means of full sized stress-strain curves at high magnification at normal testing speed. It has brought about an entirely new approach to materials testing practice.

It has incidentally increased the usefulness of the testing machine for the study of materials in the plastic range, useful in determining susceptibility to development of stretcher-strain in sheet metals used in deep drawing. It has aided in the study of characteristics of ferrous and non-ferrous alloys in different stages of working and heat treating, including elevated temperature tests.

More than that—it has made the testing machine a more vital element in industrial purchasing, manufacturing and sales activities today, because its easily secured, indisputable records, blue printed in as many copies as necessary, are the literal autographs of the materials tested. They may be kept as permanent records of each routine test. They may be supplied with materials sold, in lieu of a test report. They may be used to accompany a proposal in business solicitations. They may be submitted by a purchaser to a supplier accompanying rejected materials.

Typical users of Southwark Stress-Strain Recorders for such purposes are: Union Carbide and Carbon, U. S. Steel Research Laboratories, American Sheet and Tin Plate, Republic Steel, Pittsburgh Crucible, Allegheny Steel, International Nickel, Bethlehem Steel, Carpenter Steel, Midvale, Carnegie Steel, American Steel and Wire, Revere Copper and Brass, Aluminum Company, Barber Asphalt, Ohio Insulator, Corning Glass, U. S. Rubber, Westinghouse Electric, National Cash Register, and others including a long list of U. S. Government Agencies. Bulletin No. 94 describes Southwark Stress-Strain Recorders in detail. Ask for your copy.

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SOUTHWARK DIVISION, PHILADELPHIA
Pacific Coast Representative: THE PELTON WATER WHEEL CO., San Francisco

SOUTHWARK

Electric furnaces

(Continued from page 188)

advent of the high-strength, oxidation-resisting alloys of chromium (of electric furnace origin) with iron and nickel.

Electric heat has made it practicable to build furnaces in which it is possible to maintain such control of the atmosphere that copper, steel and other metals may be annealed or otherwise heat treated at high temperatures and after cooling within the furnace come out as bright as when put in. These "bright annealing" processes are being applied to such diverse products as fine copper wire, such as may be found in one's telephone transmitter, and strip sheet steel from which the fenders and body of the new automobile are stamped.

"Copper brazing" is another modern electric furnace development by means of which steel parts may be joined. The parts, fitted together and with bits of copper wire disposed along the joints, are heated at a temperature somewhat above the melting point of copper in a protective atmosphere, such as hydrogen for example. When the copper melts it flows by capillarity into the joint spaces, much as ink is absorbed into blotting paper. When the assembly has cooled its component parts are firmly joined by films of copper which are gas tight and very strong. This copper brazing process has been used for joining the parts of mechanical refrigerators and as a means for making vacuum tight the welded joints of many of the new metal radio tubes. These instances again show how closely electric furnace products are knit into our daily lives.

In conclusion it may be interesting to mention a few of the things which have come to be a part of our everyday life because of the special new materials which the electric furnace has made possible:

Aluminum cooking utensils
Tungsten filament electric lights
Electrically heated home appliances
Automobiles
Radio
Aerial transportation

The application of electric power to the creation of new metallurgical products and new ways of fabricating them, again electrical, has altered our ways of living to a degree that is astonishing. It appears that further and more rapid changes will result.

IMPROVE RESULTS WITH HOLDEN LIGHT CASE

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Castings for railroads

(Cont. from page 183) the fact that they had been operating along the Atlantic seaboard adjacent and subject at all times to salt spray and the action of sulphurous acid formed by the coal and water carried in the tender. In fact, the siliceous coating of molding sand fused into the surface of the steel at the time of manufacture and forming its protective skin was still intact. The advantages of these cast steel tender frames were quickly recognized by the railroad men throughout the United States and Canada, and their use today is so general that they may be said to be standard.

The second example, involving probably the most active corrosion to which a railroad freight car is subjected, relates to the transportation of bulk sulphur.

In the southwestern section of the United States, this commodity is transported in open top gondola cars from the deposits to the Gulf ports. A great many cars were originally built for this service with fabricated rolled steel frames and wooden floor and superstructure. These rolled steel frames were in need of constant attention, quickly deteriorated and lasted only a short time.

The Santa Fe railroad, which handles a considerable portion of this traffic, substituted a one-piece cast steel underframe such as shown in the halftone on page 181 for the built-up structure in 150 cars in 1927. The results were so satisfactory that in 1929 this railroad ordered 150 more cast steel underframes. These cars have wooden sides and floors, and have been in continuous use carrying sulphur during the intervening time, withstanding this most severe corrosive action and continuing to give a splendid account of themselves.

Everyone is familiar with the fact that for reasons of safety and to cut maintenance costs the old arch bar sideframe has been ruled off the trucks in favor of integral, cast steel sideframes, built to stand up under real punishment. Instances where cast steel, due to its excellent performance record, has been called upon to shoulder more and more the burdens of American railroading still multiply. The trend is definitely in the direction of a wider use for industry's brawniest cast-to-shape material, with steel foundrymen cooperating with the railroads all along the line.

RIVERSIDE

custom-made

ALLOYS

● RIVERSIDE Phosphor Bronze, Nickel Silver and Beryllium Copper differ from other brands in the same manner in which custom-made shoes differ from stock models. During this Company's 38 years experience in developing and producing specially balanced alloys, it has been definitely established that there is no one standard alloy to cover diversified applications.

RIVERSIDE Metals are not produced by routine methods. Each consumer's needs are considered individually, and the most satisfactory alloy, grade, temper and form is developed in our Metallurgical Research Department. Samples are then submitted for the customer's approval.

To such a service we bring the collective ability, experience and facilities of an organization which is recognized as one of the country's leading producers of high quality Phosphor Bronze, Nickel Silver and Beryllium Copper in the forms of sheet, strip, wire and rod.

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Good Tools
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Monroe & Jefferson Sts.

TORONTO
59 Frederick St.

Carbometer

(Cont. from page 162) the quick carbometer test advance information is available on which ore additions can be computed. After the ore has had sufficient time to work through the bath, more carbometer tests are taken and additional ore added if necessary. Over-oxidation of the bath is thus avoided and the iron oxide content of the slag more readily controlled. The carbon reaction is therefore followed closely, and such non-oxidizable alloy additions as are made before the preliminary deoxidation are properly timed, and complete solution attained.

Carbometer samples are likewise taken to determine the time for reboil additions and on this information the slag is shaped up so that the additions can be made at the proper time. After the reboil addition, more tests are taken to determine the proper time for proceeding with the final furnace deoxidation. "Final preliminary tests" are sent to the chemical laboratory and, based on these laboratory analyses, the manganese and other alloys are added and the heat tapped.

Electric Furnace Practice—In making electric furnace heats, the instrument is particularly useful between the melt and slag-off periods. In these heats a sample for the chemical laboratory and a carbometer test bar are taken when the heat is melted. From the information given by the latter the heat can be slagged off as soon as the steel has reached the right temperature, providing the carbon is correct. If the carbon is too high, ore must be added, and additional carbometer tests are taken until the carbon content is correct. Over-oxidation of the bath is avoided and a considerable saving in time is made. Further tests are made at slag-off; they control to some extent the addition of alloys between slag-off and tap. As with openhearth heats, laboratory checks are taken simultaneously.

As furnace operators gain experience in the use of the carbometer, they appreciate its possibilities for time saving as well as quality control, and realize that definite scientific tests must inevitably give more consistent and more accurate results than even long years of experience in judging furnace conditions by eye. The new instrument does not replace any men, nor does it eliminate the necessity for skilled furnace operators, but it does make quality control more exact. At the same time its use speeds up furnace operation, thereby increasing production.